WILLIAM THOMAS LOCKE TRAVERS.

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TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

1902

VOL. XXXV.

(EIGHTEENTH OF NEW SERIES)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

BY

SIR JAMES HECTOR, K.C.M.G., M.D., F.R.S.
DIRECTOR

WELLINGTON
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CORRIGENDUM.

Page 92, line 14. *For* the dishes *read* tin dishes.

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NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867."

ABSTRACTS OF RULES AND STATUTES.

GAZETTED IN THE "NEW ZEALAND GAZETTE," 9TH MARCH, 1868.

SECTION I.

Incorporation of Societies.

1. No society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1867," unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than fifty pounds sterling annually for the promotion of art, science, or such other branch of knowledge for

which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the Chairman for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £50.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the Museum and Library of the New Zealand Institute.

4. Any society incorporated as aforesaid, which shall in any one year fail to expend the proportion of revenue affixed in manner provided by Rule 3 aforesaid, shall from thenceforth cease to be incorporated with the Institute.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and may then be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a.*) The publications of the Institute shall consist of a current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute," and of transactions, comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Institute shall have power to reject any papers read before any of the incorporated societies.

(*c.*) Papers so rejected will be returned to the society in which they were read.

(*d.*) A proportional contribution may be required from each society towards the cost of publishing the Proceedings and Transactions of the Institute.

(*e.*) Each incorporated society will be entitled to receive a *proportional* number of copies of the Proceedings and Transactions of the Institute, to be from time to time fixed by the Board of Governors.

(*f.*) Extra copies will be issued to any of the members of incorporated societies at the cost-price of publication.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. Subject to "The New Zealand Institute Act, 1867," and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the Chairman and countersigned by the Secretary of any society, accompanied by the certificate required under Rule No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing rules of the Institute are complied with by the society.

Section II.

For the Management of the Property of the Institute.

9. All donations by societies, public departments, or private individuals to the Museum of the Institute shall be acknowledged by a printed form of receipt, and shall be duly entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

10. Deposits of articles for the Museum may be accepted by the Institute, subject to a fortnight's notice of removal, to be given either by the owner of the articles or by the Manager of the Institute, and such deposits shall be duly entered in a separate catalogue.

11. Books relating to natural science may be deposited in the Library of the Institute, subject to the following conditions:—

(*a.*) Such books are not to be withdrawn by the owner under six months' notice, if such notice shall be required by the Board of Governors.

(*b.*) Any funds especially expended on binding and preserving such deposited books at the request of the depositor shall be charged against the books, and must be refunded to the Institute before their withdrawal, always subject to special arrangements made with the Board of Governors at the time of deposit.

(*c.*) No books deposited in the Library of the Institute shall be removed for temporary use except on the written authority or receipt of the owner, and then only for a period not exceeding seven days at any one time.

12. All books in the Library of the Institute shall be duly entered in a catalogue, which shall be accessible to the public.

13. The public shall be admitted to the use of the Museum and Library, subject to by-laws to be framed by the Board.

Section III.

The laboratory shall for the time being be and remain under the exclusive management of the Manager of the Institute.

Section IV.

(Of Date 23rd September, 1870.)

Honorary Members.

Whereas the rules of the societies incorporated under the New Zealand Institute Act provide for the election of honorary members of such societies, but inasmuch as such honorary members would not thereby become members of the New Zealand Institute, and whereas it is expedient to make provision for the election of honorary members of the New Zealand Institute, it is hereby declared,—

1. Each incorporated society may, in the month of November next, nominate for election, as honorary members of the New Zealand Institute, three persons, and in the month of November in each succeeding year one person, not residing in the colony.
2. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the Manager of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.
3. From the persons so nominated the Governors may select in the first year not more than nine, and in each succeeding year not more than three, who shall from thenceforth be honorary members of the New Zealand Institute, provided that the total number of honorary members shall not exceed thirty.

ROLL OF INCORPORATED SOCIETIES.

NAME OF SOCIETY.	DATE OF INCORPORATION.
Wellington Philosophical Society	10th June, 1868.
Auckland Institute	10th June, 1868.
Philosophical Institute of Canterbury	22nd Oct., 1868.
Otago Institute	18th Oct., 1869.
Westland Institute	21st Dec., 1874.
Hawke's Bay Philosophical Institute	31st Mar., 1875.
Southland Institute	21st July, 1880.
Nelson Institute	20th Dec., 1883.

OFFICERS OF INCORPORATED SOCIETIES, AND EXTRACTS FROM THE RULES.

WELLINGTON PHILOSOPHICAL SOCIETY.

Office-bearers for 1903.—*President*—Professor Easterfield; *Vice-presidents* — Sir J. Hector, K.C.M.G., M.D., F.R.S., and G. Hogben, M.A.; *Council*—H. N. McLeod, E. Tregear, F.R.G.S., Martin Chapman, R. C. Harding, G. V. Hudson, C. E. Adams, B.Sc., and Professor Kirk; *Secretary and Treasurer*—A. H. Gore; *Auditor*—Thomas King.

Extracts from the Rules of the Wellington Philosophical Society.

5. Every member shall contribute annually to the funds of the Society the sum of one guinea.

6. The annual contribution shall be due on the first day of January in each year.

7. The sum of ten pounds may be paid at any time as a composition for life of the ordinary annual payment.

14. The time and place of the general meetings of members of the Society shall be fixed by the Council, and duly announced by the Secretary.

AUCKLAND INSTITUTE.

Office-bearers for 1903. — *President*—Professor A. P. W. Thomas, F.L.S.; *Vice-presidents* — E. Roberton, M.D., J. Stewart, M.I.C.E.; *Council*—Professor F. D. Brown, C. Cooper, H. Haines, F.R.C.S., E. V. Miller, T. Peacock, D. Petrie, J. A. Pond, J. Reid, Professor H. W. Segar, Professor H. A. Talbot-Tubbs, J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.

Extracts from the Rules of the Auckland Institute.

5. Any person desiring to become a member of the Institute shall be proposed and seconded by two members of the Institute, and shall be balloted for at the next meeting of the Council.

6. The annual subscription shall be one guinea. Members may at any time become life-members by one payment of ten guineas in lieu of future annual subscriptions.

9. The annual subscription shall become due on the first day of April for the year then commencing. The first year's subscription of a new member shall become due on the day of his election.

30. An annual general meeting of the Institute, convened by advertisement or circular, shall be held in the month of February in each year.

32. Ordinary meetings for the reading of papers, and for transacting the general business of the Institute, shall be called at such times as the Council shall decide.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

OFFICE-BEARERS FOR 1903.—*President*—Professor Charles Chilton, D.Sc.; *Vice-presidents*—J. B. Mayne, B.A., A. E. Flower, M.A. B.Sc.; *Hon. Secretary*—C. Coleridge Farr, D.Sc.; *Hon. Treasurer*—Professor Charles Chilton, D.Sc.; *Council*—Miss M. F. Olliver, M.A., Captain F. W. Hutton, F.R.S., Professor W. P. Evans, Ph.D., Dr. W. H. Symes, L. Cockayne, R. Speight, M.A., B.Sc.

Extracts from the Rules of the Philosophical Institute of Canterbury.

8. Every member of the Institute other than honorary shall pay one guinea annually as a subscription to the funds of the Institute. The subscription shall be due on the 1st January in each year.

9. Members may compound for all annual subscriptions of the current and future years by paying ten guineas.

15. The ordinary meetings of the Institute shall be held monthly during the months from May to November, both inclusive, on such day as the Council may determine.

OTAGO INSTITUTE.

OFFICE-BEARERS FOR 1903.—*President*—A. Hamilton; *Vice-presidents*—Professor Benham and George M. Thomson; *Hon. Secretary*—Dr. P. Marshall; *Hon. Treasurer*—Willi Fels; *Council*—A. Bathgate, C. W. Chamberlain, F. R. Chapman, J. S. S. Cooper, James C. Thomson, D. Waters, and Dr. Hocken; *Hon. Auditor*—D. Brent.

Extracts from the Constitution and Rules of the Otago Institute.

2. Any person desiring to join the society may be elected by ballot, on being proposed in writing at any meeting of the Council or society by two members, and on the payment of the annual subscription of one guinea for the year then current.

5. Members may at any time become life-members by one payment of ten pounds and ten shillings in lieu of future annual subscriptions.

8. An annual general meeting of the members of the society shall be held in January in each year, at which meeting not less than ten members must be present, otherwise the meeting shall be adjourned by the members present from time to time until the requisite number of members is present.

(5.) The session of the Otago Institute shall be during the winter months, from May to October, both inclusive.

WESTLAND INSTITUTE.

Office-bearers for 1903.—*President*—J. B. Lewis; *Vice-president*—T. W. Beare; *Hon. Treasurer*—R. McNaughton; *Trustees*—Messrs. Clarke, Heinz, Michel, Morton, Park, Perry, Macfarlane, Mahan, Dunne, Solomon, Dr. Macandrew, and Dr. Teichelmann.

Extracts from the Rules of the Westland Institute.

3. The Institute shall consist (1) of life-members—*i.e.*, persons who have at any one time made a donation to the Institute of ten pounds ten shillings or upwards, or persons who, in reward of special services rendered to the Institute, have been unanimously elected as such by the committee or at a general half-yearly meeting; (2) of members who pay two pounds two shillings each year; (3) of members paying smaller sums, not less than ten shillings.

5. The Institute shall hold a half-yearly meeting on the third Monday in the months of December and June.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

Office-bearers for 1903.—*President*—J. P. D. Leahy, M.B., M.S., B.A., D.P.H.; *Vice-president*—T. C. Moore, M.D.; *Council*—W. Dinwiddie, H. W. Antill, H. Hill, B.A., F.G.S., F. Hutchinson, jun., J. S. Large, T. Tanner; *Hon. Secretary*—James Hislop, District School; *Hon. Treasurer*—J. W. Craig; *Hon. Auditor*—G. White; *Curator*—E. W. Andrews.

Extracts from the Rules of the Hawke's Bay Philosophical Institute.

4. The annual subscription for each member shall be one guinea, payable in advance on the first day of February in each year.

6. Members may at any time become life-members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

(5.) The session of the Hawke's Bay Philosophical Institute shall be during the winter months from May to October, both inclusive; and ordinary meetings shall be held on the second Monday in each of those six months, at 7.30 p.m.

SOUTHLAND INSTITUTE.

Office-bearers. — *Trustees* — Ven. Archdeacon Stocker, Rev. John Ferguson, Dr. James Galbraith.

NELSON INSTITUTE.

Office-bearers for 1903.—*President*—H. W. Robinson; *Vice-president*—D. Grant; *Hon. Secretary and Treasurer*—A. J. Redgrave; *Librarian*—B. Reeves.

Extracts from the Rules of the Nelson Institute.

4. Members shall be elected by ballot.

6. The annual subscription shall be one guinea.

7. The sum of ten guineas may be paid in composition of the annual subscription.

16. Meetings shall be held on the second Monday in every month.

23. The papers read before the Society shall be immediately delivered to the Secretary.

IN MEMORIAM.

William Thomas Locke Travers, F.L.S. (1819–1903), was born at Castleview, near Newcastle, in County Limerick, on the 9th January, 1819, and was educated at St. Servan College in France. When seventeen years old he joined the Spanish Legion during the Carlist war, and served with distinction in the 2nd Regiment of Lancers till 1839. During part of the time he was aide-de-camp to the general of his division, and for his services was decorated with the Grand Cross of the Order of Cambodia. In 1844 he was called to the bar in London, and in 1849 emigrated to Nelson, and became District Court Judge there. Having resigned that office, he was, in 1854, elected member of the House of Representatives for Nelson in the first Parliament of New Zealand, and for a time held office as Attorney-General. In 1856 he was elected to represent Waimea. In 1860 he moved to Christchurch, where he practised his profession, and was elected M.H.R. for that city. He was also a member of the Canterbury Provincial Council and of the Provincial Executive. In 1869 he settled in Wellington, and represented that city in Parliament for several years. He was one of the chief promoters of the New Zealand Institute in 1867, was a member of the Board of Governors from that time, and for many years was honorary treasurer. The formation of the Colonial Botanic Garden at Wellington was largely due to his skill and enthusiasm; and he took a leading part in the promotion of acclimatisation societies, and of many other useful institutions. He was a member of the Council of the Wellington Philosophical Society for thirty-two years, was five times elected president, and was the retiring president when he met with the accident which caused his death on the 26th April, 1903.

List of the principal papers communicated to the Wellington Philosophical Society by W. T. L. Travers:—

Address, Wellington, IV., 356; X., 519, 539; XXIX., 111.
Birds, Habits of, IV., 206.
Botany, Comparisons in, between Canterbury, Nelson, and Marlborough, I., Pt. 3, 17; 2nd ed., 174.
Cassinia leptophylla, VI., 248.
Cause of the Warmer Climate which existed in High Northern Latitudes during Former Geological Periods, X., 459, 470.
Civilisation, Effects of, on New Country, II., 299; III., 326.
Chatham Islands, IV., 63.
Chatham Islands, Avifauna and Flora, V., 212.
Distribution of the Organic Productions of New Zealand, XVI., 461.
Distribution, within the New Zealand Zoological Sub-region, of the Birds of the Orders Accipitres, Passeres, Scansores, Columbæ, Gallinæ, Struthiones, and Grallæ, XV., 178.
Earthquakes and Volcanoes, Notes in reference to the Primary Causes of the Phenomena of, XIX., 331.

Eels, III., 120.
Flesh Fly, III., 116.
Food-plants used by Civilised Man as compared with those used in Prehistoric Times, Notes on the Difference in, XVIII., 30.
Glaciers, Extinct, VI., 297.
Glaciation, Pleistocene, VII., 409.
Great Flood of February, 1868, XIV., 76.
Hybridization, I., 89 ; 2nd ed., 31.
Insectivorous Birds as the Friends of the Agriculturist: Presidential Address in 1902, XXXV., 1
Lake Districts of the Province of Auckland, IX., 1.
Maori Traditions, IV., 51.
"Marshlights," Supplement to Mr. R. C. Harding's Paper on, XXX., 92.
Microbes, Remarks on Pathogenic, and the Means of preventing Diseases originating in their Introduction into the System, XXII., 55.
Moa, Extinction of the, VIII., 58.
Moriori Canoes, IV., 354.
Moriori Traditions, Manners, and Customs, IX., 15.
Mr. J. T. Thomson's System of Survey, from a Legal Point of View, IX., 280.
Paryphanta in New Zealand, Notes on the Larger Species of; with some Remarks on the Distribution and Dispersal of Land Shells, XXVII., 224.
Patellidæ, Notes on, with reference to Species found on Rocks at Island and Lyall Bays, XXX., 309.
Phormium tenax, I., 168 ; 2nd ed., 114.
Photography, IV., 160.
Podiceps cristatus, III., 113.
Polygonum aviculare, V., 310.
Sand-dunes on the West Coast of the Provincial District of Wellington, XIV., 89.
Sand-worn Stones, II., 247.
Scientific and Material Progress in New Zealand during the Victorian Era, XXX., 1.
Te Rauparaha, Life and Times of, V., 19.
Tidal Wave of 11th May, 1877, X., 522.

IN MEMORIAM.

Thomas Mason (1818–1903), a native of England, arrived in Wellington in 1841, and settled at Taita, in the Hutt Valley. He had been Chairman of the Hutt County Council, and was at one time a member of the House of Representatives for the Hutt District. As a horticulturist he had a wide reputation, having the finest private botanical collection in the colony. He was for over twenty years a member of the Board of Governors of the Institute, and was Chairman of the Board at the time of his death. He has contributed papers on horticultural subjects which have been published in the Transactions, and the current volume contains his last contribution.

THOMAS MASON.

See p. xx.

CIRCULAR.

NEW ZEALAND INSTITUTE.

SECRETARIES of societies are requested to see that each paper read is indorsed with—

(1.) The date of reading;
(2.) The name of author;
(3.) The postal address of author.

The mail arrangements of the colony are now so complete that, in cases where it is thought desirable, proofs can be generally sent to authors for revision, provided the author's postal address is indorsed on the manuscript.

Any author whose address is not indorsed on his paper must not expect to receive proofs for revision.

Corrected proofs must be promptly returned by the author, otherwise the editor cannot be responsible for authors' corrections being applied. Material alterations should not be inserted, but in important cases, where the rights of others are not specially affected, addenda may be made.

Illustrations should be prepared so that they can be reproduced by photo-lithography or by process blocks. The size should be 7 in. by 4 in., or a multiple thereof, that being the size of the plates as published. If the originals, either drawings or photographs, have not such proportions, great extra expense is incurred, and the result is often not satisfactory. The name of the author should always be written on the back of the original drawing or photograph, together with the subject. The full description for letterpress should be written on a separate sheet, and not on the illustration itself; and the illustrations (if more than one) and descriptions should be similarly numbered.

JAMES HECTOR,
Manager.

TRANSACTIONS

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1902.

I.—MISCELLANEOUS.

Art. I.—*The Bird as the Labourer of Man.*

By W. T. L. Travers, F.L.S.

[*Presidential Address to the Wellington Philosophical Society, 5th August, 1902.*]

After you had done me the honour of electing me to the position of President of this Society for the current year I resolved to deal, in my opening address, with the structure and action of the geysers which form so attractive a feature of the country stretching from Tokaanu to White Island, including the Rotorua district, and incidentally with some of the remarkable features which have characterized the recent volcanic outbursts in Martinique and St. Vincent, and to again call your attention to the prime causes of all such phenomena. It may be recollected by some of you that I brought this subject before our Society in papers read during the sessions of 1877 and 1878; but the views which I then ventured to submit were not favourably received by such of our members as claimed to possess any large degree of geological knowledge, chiefly on the ground that Sir Charles Lyell had always treated such questions as not being properly within the range of geological inquiry. It was, therefore, with no little gratification that I read the address delivered by Professor Sollas to the geological section of the British Association in 1900, in which he propounded precisely similar views, and pointed out that, at the present day, geologists are no longer justified in asserting that cosmogony is alien to geology.

But a question the proper solution of which is certainly of far greater importance to this colony has recently arisen, and

has induced me to deal with a different and more useful practical subject—namely, whether the attempt now being made to obtain legislative authority to exterminate our small birds is justifiable or not? The title which I have given to this address is taken from a work on ornithology written by Michelet, the great French historian, who added to the distinction which he attained in that character, that of an eminent practical writer on natural history.

Those who have had the advantage of reading his work will have seen that it was specially intended to demonstrate the enormous advantages which man derives, both directly and indirectly, from the labours of the bird, and to impress upon him the fact that the wanton destruction of these beautiful and useful creatures is not only grossly cruel, but is surely followed by disaster to the destroyer; and it is my object in this address to show that, if the proposed legislation be adopted and effectively carried out, it will certainly inflict disaster not only upon those through whose ignorance and prejudices it is being promoted, but practically upon the whole population of the colony, and I cannot but think that if such a result be even possible it was incumbent upon those who are promoting it to have made careful inquiries into the grounds of objection raised against the birds before proceeding to the length now contemplated. In order, however, to deal fairly with the questions at issue it was necessary that I should first ascertain whether the proposed legislation is directed against small birds generally or against some special bird or birds; and, if the latter, then to inquire into the nature of the offences of which they or it are accused.

I have taken some pains to obtain a reply to these questions, and the common answer to the first by those who support the proposed legislation is, "the sparrow." When asked what are the special offences for which the sparrow deserves the condign punishment intended for him, the reply is, "We are told by the farmer and the fruit-grower that he does the most serious injury to their crops without affording any compensation whatsoever for so doing"; and they add that "not only in New Zealand but in other countries he is looked upon by the farmer and the fruit-grower as an impudent thief, without a redeeming feature in his character." Certain other birds, and especially the blackbird and green-linnet, are also looked upon as injurious, but for downright wickedness not one of them is a patch upon the sparrow.

Now, assuming that the extermination of the sparrow is really the principal object aimed at by the intended legislation, I propose to point out generally, first, the nature and extent of the injuries done to our animal and vegetable productions by insects; and, second the uses of insectivorous

birds, and particularly the sparrow, in mitigating such injuries in this country. This subject is not new to me. Many years ago, whilst I was a member of the House of Representatives, similar charges were made against the sparrow, and my reply was as follows: "War is to be waged against the sparrows under the authority of Parliament. The following utterances show the wisdom brought to bear in discussing the question: The Hon. Mr. Chamberlain says that the hawk is the natural enemy of the sparrow, a deduction, no doubt, from the name 'sparrow-hawk,' applied to one species of hawk in this country; but no New Zealand hawk that I know of ever pursues a sparrow. Mr. Oliver tells us that it was a mistake to introduce the sparrow, and so does Mr. Gray. Mr. Miller says that none but the agriculturist was fit to discuss the question, and drew a comparison between the sparrow and the starling, which was about as appropriate as if he had attempted to compare the sparrow with the elephant. Mr. Acland said the sparrow did not destroy insects. Mr. Holmes read some extracts in support of his opinions against the sparrow, and I could supply him with any quantity more of the same kind, emanating from equal ignorance of the subject. It would be well if honourable gentlemen, in dealing with this question, would take the trouble to read the evidence given before a Committee of the House of Lords on the subject of sparrow clubs in England, and if they should still entertain any respect for the intelligence of that august body, they would probably be disposed to change the opinions above expressed. Not many years ago the agriculturists of Hungary succeeded in getting the sparrow proscribed by law, and he disappeared from the land. Within five years from that time the Government was compelled to spend 230,000 rix dollars in reintroducing him from other countries. In the North Island and in the northern parts of the South Island the cultivation of valuable deciduous trees was practically impossible until the large Cicada had been greatly reduced in numbers, and if Mr. Acland had seen, as I and many others have, the sparrow actively engaged in destroying these creatures and devouring them he might probably change his opinion. The nestling sparrow cannot eat hard food, and careful observation has shown that a pair of parent sparrows will bring upwards of three thousand insects to the nest in the course of a single day to feed its brood." I notice that the same nonsense is still uttered upon the subject, whilst not a tittle of evidence is adduced in support of it.

Now, in order that we may fully understand the assistance which the bird can afford to man in the prosecution of the incessant war in which he is undoubtedly engaged against

injurious insects, it is necessary that we should know and appreciate the strength and resources of the enemy he has to meet. To this end I purpose to call attention to the number and nature of the hosts which are always threatening the produce of our cultivations. As you are aware, all true insects are comparatively small animals belonging to the articulate sub-kingdom having the body divided into three portions, from which fact the title "insecta" has been applied to them. They are, in general, covered with a coriaceous or horny integument, serving as an external skeleton. They are capable for the most part of flight, having either two or four wings, and they usually undergo three transformations from egg to maturity. These characters may not always be evident, yet in no instance are they decidedly and truly absent. Departures in degree from a given type and modifications in the detail of structure are met with in every class of animal life, but the essentials upon which the claim of species is in any case founded remain—subject to the law of evolution—practically inviolate. As in the case of the bat, with its structure for flight, and of the whale, with its oceanic habits, these apparently abnormal habits do not remove them from among the Mammalia.

It has been said by a great entomologist that insects are Nature's favourite productions, in which, in order to manifest her skill and power, she has combined all that is either beautiful and graceful, interesting and alluring, or curious and singular in every other class of her children. To these, her valued miniatures, she has given the most delicate touch and highest finish of her pencil. Nor has she been lavish only in ornamenting these privileged tribes. In other respects she has been equally unsparing of her favours. To some she has given horns nearly the counterparts of those of various quadrupeds; some are covered with bristles, others with spines; some are of the richest hues, sparkling like the ruby, the topaz, the sapphire, and the amethyst in the rays of the sun; some gleam in polished armour—

> Like some stern warrior formidably bright,
> Their steely sides reflect a gleaming light;

others are dull of colour and of strange form and aspect; some resemble withered leaves or bits of stick, and find security in the resemblance.

To leap, to run, to bore into the ground or drive galleries through timber, to fly through the air, to gambol in the water and dive and swim are among the endowments of insects. Some build structures more wonderful than the pyramids; some gleam with phosphorescent radiance, and many are armed with poisonous weapons. They furnish us with silk,

wax, honey, lac, cochineal, and the gall-nut. Some hold an important place in the Pharmacopœia, some are eaten by various tribes of men, and multitudes furnish food to the beasts of the earth and to the birds of the air, to the reptile tribes, to the fishes, and to the more powerful of their own class.

For the purposes of this paper, however, it is only necessary to divide the whole class into those which are and those which are not injurious to man. Unfortunately, the greater number falls under the first of these distinctions, and accordingly we find that Kirby and Spence, in their charming "Introduction to Entomology," devote no less than five entire epistles to the injuries we sustain from insects, whilst two only are sufficient to describe the benefits they yield. The former contain an appalling array; the injuries done to us in our field crops, in our gardens, in our orchards, in our woods and forests, not to mention those which attack our live-stock or our persons, are indeed well calculated to impress us with the truth of the Oriental proverb that "the smallest enemy is not to be despised."

In relation to the numbers of insects alike in tropical and sub-arctic areas, I venture to make the following quotations: Michelet, speaking of tropical insects, says, "In these climates the insect is the greatest curse. Insects everywhere and in everything; they possess an infinity of means for attacking us; they walk, swim, glide, fly; they are in the air, and you breathe them. Invisible, they make known their presence by the most painful wounds. The hardiest of men, the buccaneers and filibusters of old, who carried on their nefarious doings chiefly within tropical areas, declared that of all dangers and of all pains they dreaded most the wounds of insects. Frequently intangible, and even invisible, they are destruction under an unavoidable form. How shall we oppose them when they make war upon us in legions? Their means of offence, too, are varied and terrible. No chirurgical implement invented by modern art can be compared with the monstrous armour of tropical insects; their pincers, their nippers, their teeth, their saws, their horns, their augurs, all the tools of combat and dissection with which they come armed to the battle, and with which they labour, pierce, cut, rend, and finely partition with skill and dexterity, are only equalled by their furious ravenousness. In those lands of fire where the rapidity of decomposition renders every corpse dangerous, where death threatens life, these terrible accelerators of the disappearance of animal bodies multiply *ad infinitum.* A corpse scarcely touches the earth before it is seized, attacked, disorganized, dissected. Only the bones are left. They are active hunters and insatiable gluttons. Compared

with them, the tiger, the lion, and the vulture are mild, sober, moderate creatures; for what is any of these in the presence of an insect which, in four-and-twenty hours, consumes thrice its own weight?"

In temperate regions, too, the war of the insect against man is equally desperate and continuous. Not many years ago the public papers in Europe were occupied with articles expressing the most gloomy fears for the noble oak and pine forests of Germany. It was stated that millions of trees had already fallen under the insidious attacks of a minute beetle which laid its eggs in the bark, whence the larvæ penetrated between the bark and the wood, destroying the vital connection between those parts, interrupting the course of the sap and inducing rapid decay and speedy death.

In the North of France the public promenades were almost everywhere shaded by avenues of noble elms. In very many cases these trees were fast disappearing before the assaults of a similar foe; and the grand old elms of the London parks were becoming so thinned that great alarm was felt, and the resources of science employed for checking the mischief. Fifty thousand trees, chiefly oaks, were similarly destroyed in the Bois de Vincennes, near Paris. In all these cases the minute but mighty agent was some species or other of beetle of the genus *Scolytus*. In Servia and the Banat a minute fly occurs from whose destructive assaults on cattle the inhabitants periodically suffer immense loss. A traveller arriving at Golubacs, on the Danube, thus speaks of it: "Near this place we found a range of caverns famous for producing the poisonous fly too well known in Servia and Hungary under the name of the Golubascer fly. These singular and venomous insects, somewhat resembling mosquitos, generally make their appearance during the first great heat of the summer in such numbers as to appear like vast volumes of smoke. Their attacks are always directed against every description of quadruped, and so potent is the poison they communicate that even an ox is unable to withstand its influence, for he always expires in less than two hours. This results not so much from the virulence of the poison as that every vulnerable part is simultaneously covered with these most destructive insects, when the wretched animals, frenzied with pain, rush wildly through the fields till death puts a period to their sufferings, or they accelerate dissolution by plunging headlong into a river."

Perhaps worse, however, than these, or any of them, are mosquitos, which, regardless alike of tropical heat and arctic cold, swarm in countless millions under both conditions; not that their virulence or fatality equals that of the tsetse of South Africa or the zimb of Abyssinia, but because they are most universally distributed. Those, terrible as they are, are limited

to certain districts, but the mosquito is ubiquitous, and is everywhere a pest and torment. One needs to spend a night among mosquitos to understand what a true plague of flies is. Hundreds of travellers might be cited on the subject, and if I adduce the following testimony it is not because it is the strongest I could find, but because it is one of the most recent, and therefore least known: Mr. Atkinson, who has laid open to us the most magnificent scenery of the world, and the most inaccessible, to whom neither fearful chasms and precipices, nor boiling torrents, nor swift rivers, nor earthquakes and furious storms, nor eternal frost and snow, nor burning waterless steppes, nor robbers, nor wild beasts presented any impediment, fairly confesses his conqueror in the mosquito. The gnat alone, of all creatures, elicits from him a word of dread: he could not brave the mosquitos. Over and over he tells us in his accounts of his mountain scrambles that the mosquitos were there "in millions," that they were "taking a most savage revenge on him for having sent his horses out of their reach," that they were "devouring him," that he "neither dared to sleep nor to look out," that "the humming sound of the millions was something awful," that he found himself "in the very regions of torment, which it was utterly impossible to endure," that "the poor horses stood with their heads in the smoke as a protection against the pests," and that "to have remained on the spot would have subjected them to a degree of torment neither man nor beast could endure, so that they were obliged to retreat." "I wish I could say," he feelingly adds, "that we left the enemy in possession of the field. Not so; they pursued us with bloodthirsty pertinacity until we reached some open meadows, when they were driven into their fenny region by a breeze, I hope to prey on each other."

Leaving these generalities, I will now deal shortly with the subject in its application to our own Islands. I arrived here in 1849, and first settled in Nelson. The area of land then under cultivation was small, but even at that early date most of the grains and vegetables and many of the fruits common in England and France were successfully cultivated. All, however, were subject to the attacks of injurious insects of various species, some imported and some indigenous. The large native locust, of which it is difficult at present to obtain a specimen, was then very common and very injurious, whilst grasshoppers existed in countless numbers. But the chief injury was done by various forms of *Coleoptera* and *Lepidoptera*, both foreign and indigenous. Wheat always escaped better than oats or barley,* the latter especially yielding only a very

* The Hessian fly had not then appeared

casual crop. The fruit-trees, vines, currant, raspberry, and gooseberry bushes bore well, and apples of many kinds, plums, peaches, and apricots were particularly abundant and well flavoured. Hops, which have always been a specialty in Nelson, also yielded large and well-flavoured crops, and were not molested by the fly; but in the ten years during which I remained there an appreciable increase took place in the injuries caused by insects, and, although the generally dry character of the climate, especially during the summer season, was unfavourable to the development of many injurious forms, the number both of species and individuals had increased very greatly.

In 1860 I went to reside in Canterbury, which had then been settled for between eight and nine years. Its progress had been more rapid than that of either Wellington or Nelson, because its settlers had been able to obtain from both of these every form of vegetable and fruit which was suitable for cultivation within its borders. To the northward of Christchurch, around Kaiapoi and Rangiora, in the Lincoln district, and in the immediate surroundings of Christchurch, large areas had been brought under cultivation, and yielded excellent returns; but I well remember the extraordinary clouds of moths of all kinds which rose from the ground as one walked either through the tussock-covered areas or through fields of cultivated grass. In the Rangiora district trenches were often dug to intercept millions of caterpillars when marching towards growing crops, and the ravages they committed where no means of protection existed were very serious. I left Canterbury in 1867, and have ever since resided in Wellington. By that time the numbers of destructive insects in Canterbury had been greatly diminished by the constant burning of the tussock-grasses, besides which the sparrow had been introduced and had been doing his work, and I noticed that the yield of all grain-crops had increased in proportion to the increase and spread of this most valuable ally of man.

As regards Wellington, my observations have been practically restricted to the district of the Hutt. When I first went to the district the beautiful *Cicada circinata* existed there in immense numbers. This insect is especially destructive to fruit and other trees. It deposits its eggs in lines cut somewhat deeply upon the principal branches, and the wound thus made is never healed. Two or three years after the wound has thus been made the wounded branch is sure to break at the wounded part, and the symmetry of the tree thereby seriously affected and its growth checked. This insect is still procurable, but it found a determined and constant enemy in the sparrow, which has already made it scarce. The telegraph-poles were much frequented by them, and

the noise they made when in great numbers was actually deafening.

As regards our ordinary cultivated plants, the agriculturist, the fruit-grower, and the gardener are at one in their complaints of the ravages committed by various forms of "insect pests," and the language used by Mr. French in his "Handbook of the Destructive Insects of Victoria" is equally applicable to those found in this colony. There, as here, one of the principal troubles which persons engaged in the cultivation of the soil have to contend against is the existence of innumerable pests, and he points out that the time has arrived when, if the people of that colony are to fight successfully against them, united action and constant vigilance would have to be exercised, and he especially urges that knowledge must be gained by regular and unprejudiced observation and by carefully conducted experiments. As a principal means of insuring the desired balance of nature he emphasizes the necessity for preserving insect-destroying birds. He points out that to all who are engaged in either farming or fruit-growing the preservation of their useful friends, the insect-destroying birds, is of the very greatest importance. "Nature" he says, "maintains a balance between the numbers of the birds, beasts, insects, plants, &c., in any district. If by artificial means we destroy this balance, immediately intolerable numbers of some kind remain with us, and we have to expend much money and labour to rid ourselves of the swarms which Nature was ready to dispose of for us without charge." Quoting from Mr. Tyron's valuable work on the fungus and insect pests of Queensland, where, as you know, the cattle-tick often does enormous mischief, he adds "that if the arrangements of Nature were left undisturbed the result would be a wholesome equilibrium of destruction. The birds would kill so many insects that the insects could not kill too many plants. One class is a match for the other. A certain insect was found to lay 2,000 eggs, but a single 'tom-tit' was found to devour 200,000 eggs in a year. A swallow devours 543 insects in a day, eggs and all. This is the whole case in a nutshell: the birds will do yeoman service and ask for no wages." He then adds, "How and by what means is the wholesale destruction of the insectivorous birds of Victoria to be checked? This would seem to be a somewhat difficult question to answer, for have we not already game laws; but are they carried out? To secure active co-operation in the direction of the preservation of insectivorous birds we must be able to show those interested the difference between the noxious and the beneficial; to point out to those who are engaged in our great rural industries that their interest lies in uniting to maintain the balance which Nature has given

us, and more especially to endeavour to impress upon the young people the necessity for preserving certain birds from destruction. Those unaccustomed to dissecting birds can have but a faint idea of the enormous quantity of insects which many even of the smaller birds devour, and a better acquaintance with both birds and insects would, I am sure, tend to prevent the wholesale slaughter of creatures so useful."

Let us now inquire what available force we have in this colony upon which reliance can be placed for resisting the ever-increasing army of insect enemies which threaten our field and garden crops, our orchards and fruit plantations, and our flower-beds. Apart from insect-destroying insects, such as the ichneumons, the dragon-flies, and others of the like proclivities, we have only a few insecting-eating birds, of which some are indigenous and others are imported. The indigenous birds are rarely found outside the native bush, and are now very few in number. In my garden there are two or three pairs of fantails, which are always diligent in the pursuit of food. The seagulls do much to lessen the number of destructive larvæ by following the plough in the extensive cultivations along the seaboard of the South Island. Of the imported birds, the white-eyed *Zosterops*, the blackbird, and the thrush feed upon animal food throughout the winter, but will certainly, unless prevented, take any opportunity presented to them of attacking fruit in its season. The thrushes have kept my garden free from the snail, which does mischief to the young forms of certain classes of plants; but both these birds confine themselves to the neighbourhood of plantations. The starling ranges the pastures, but does not, so far as my observation has gone, take any part in clearing the crops of grain, corn, and pulse of the insects which attack them. We are reduced, then, to the sparrow, including the recently introduced hedge-sparrow, a most valuable bird, which alone are left to protect us from the horde of insects that attack everything we grow. I keep a brigade of them, to which I give a certain amount of daily food, not sufficient, however, to diminish their diligence in the search for insects. I see the work they do in this respect. I see them during the breeding-season each day carrying hundreds of insects to their young, which could not live on any other form of food. I see my garden crops kept fairly free from injurious insects by their means and theirs only, and I do not grudge them the modicum of fruit which they take in its season. I see how difficult it is to raise fruit in this country owing to the absence of the ordinary natural checks upon the increase of the insects which prey upon it. Nature,

we know, delights in preserving a due balance between the various forms of life, whether animal or vegetable; but man, in his ignorance and wilfulness, is constantly interfering with natural operations, often falsely attributing the evil which results to anything but his own shortsightedness and folly. Hence the proposed legislation.

I will now conclude this address by quoting a passage from Michelet's work, which will show you that ignorance and selfishness are not new characteristics of the farmer. "The miserly agriculturist," he says, "is the accurate and forcible expression of Virgil. Miserly and blind in truth, for he proscribes the birds which destroy insects and protects his crops. Not a grain will he spare to the bird which during the winter hunts up the future insect, seeking out the nest of the larvæ and daily destroying myriads of future depredators, but sacks of corn to the adult insect and whole fields to the grasshoppers, which the bird would have combated! With his eyes fixed on the furrow, on the present moment, without foresight, deaf to the grand harmony which no one ever interrupts with impunity, he has everywhere solicited or approved of laws for suppressing the much-needed assistance of his labour, the insect-destroying bird. And the insects have avenged the bird, as we have seen it become necessary in many cases to recall in all haste the banished. In the Island of Bourbon, for example, a price was set on each martin's head. They disappeared, and the grasshoppers took possession of the island, devouring, extinguishing, burning up with harsh acridity all that they did not devour. The same thing occurred in North America with the starling, the protector of the maize. The sparrow even, which attacks the grain, but also defends it—the thieving, pilfering sparrow, loaded with so many insults and stricken with so many maledictions—it has been seen that without his aid Hungary would have perished, that he alone could wage the mighty war against the cockchafers and the myriad-winged foes which reigned in the low-lying lands. His banishment was revoked and this courageous militia hastily recalled, which, though not strictly disciplined, became none the less the salvation of the country."

Art. II.—*The Cultivation and Treatment of the Kumara by the Primitive Maoris.*

By Archdeacon Walsh.

[*Read before the Auckland Institute, 4th August, 1902.*]

Previous to the introduction and general distribution of European food plants—that is to say, up to the early part of the last century—the only vegetables cultivated by the Maoris were those which they had brought from their original homes in the Pacific islands—namely, the kumara (*Ipomœa chrysorrhiza*), the taro (*Caladium esculentum*), the hue (*Lagenaria vulgaris*), and the ti pore* (*Cordyline terminalis*).

Of these the first-named was by far the most valuable and important. The taro would only flourish in particular spots, and even under the most favourable conditions took a long time to come to maturity, and gave but a small return for a good deal of troublesome labour. The hue was tasteless and unsustaining; and the ti pore, in reality a tropical plant, never became properly acclimatised, and the limited quantity grown was used more as an occasional delicacy than an article of every-day food. But the kumara freely responded to care and attention in the most varied situations, and yielded a large crop of an article at once palatable, wholesome, and nutritious. With the primitive Maoris, in fact, the kumara stood in a class by itself, above and apart from everything else. As the mainstay of life it was regarded with the greatest respect and veneration. It was celebrated in song, and story, and proverb. Its cultivation and treatment called forth the utmost care and ingenuity, and were accompanied by the strictest and most elaborate religious observances.

The old customs have long passed away, and very soon all personal recollection of them will be lost. I have therefore in the present paper endeavoured to rescue a few of the most interesting facts connected with the subject from oblivion. In doing so I have been greatly helped by Mr. James Bedggood, of Kerikeri, who has not only given me the result of his own observation during a long lifetime spent in intimate relation with the Maoris, but also the information he has gleaned from some of his old native neighbours whose recollection reaches back to the primitive times. I have also gathered some facts from a very interesting paper by the late Rev. W. Colenso, F.R.S., F.L.S., &c.,† as well as from Mr. A. Hamilton's "Maori Art," and from scattered notices in

* For an account of the ti pore, see Trans. N.Z. Inst., vol. xxxiii., art. xxxi.

† Trans. N.Z. Inst., xiii., art. i.

some of the earlier books on New Zealand. I do not pretend to have by any means exhausted the subject, and shall be very glad if my paper is supplemented by those who are able to give additional information.

VARIETIES OF THE KUMARA.

A very general tradition states that, not finding the kumara on their first arrival in the country, the Maoris made an expedition back to their old home among the Pacific islands to secure a supply for cultivation. That they brought back a large and well-assorted stock is evidenced by the number of varieties they possessed. Mr. Colenso states that not less than thirty of these had come under his notice, while several of the old sorts were already known to be lost. All these varieties were well marked and permanent, and must have been produced before their introduction here, as, although occasionally flowering, the plant has never been known to seed in this country. They had each their separate name,* and were distinguished by different peculiarities in size, shape, and colour, some being valued for their superior flavour and others as giving a more abundant crop, while probably certain of them were specially adapted to local conditions of soil and situation.

As the European food plants—especially the potato—came into use the relative importance of the kumara somewhat declined, and many of the smaller varieties became gradually extinct, the cultivation being chiefly confined to a few of the larger sorts, including the "merikana" (American), so called from the American whalers, who brought it from the Pacific islands. This was a long white twisted tuber, and was the first addition to the old native varieties. Of late years the number has been still further reduced, and at the present time the "waina" (vine), a later introduction—so called from being occasionally propagated by cuttings from the vines or runners—is almost the only sort used for a general crop. This, being a very heavy yielder of robust habit, has quite taken the place of the old smaller varieties, a few of which, however, are still grown in some of the more primitive districts as a special delicacy.

SOIL AND SITUATION.

Though, of course, some are more suitable than others, roughly speaking, almost any soil will do for the kumara so long as the situation is dry and the plants are not exposed to the cold southerly winds or to the spring and autumn frosts. The heaviest crops are obtained on the sand and shingle terraces above high-water mark on the

* For a list of the names, see Colenso, *loc. cit.*, Appendix A.

sea-coast and on the low river-flats; but as the former are limited in extent and the latter are more exposed to frosts — besides taking a good while to dry up after the winter rains—advantage was taken of well-drained sheltered spots on higher ground for the early plantings, though the work of cultivation was attended by much harder labour. The volcanic lands scattered throughout the northern peninsula, where not too stony, offered every advantage; and the extent to which the cultivation on these was carried on may be judged from the large areas on which the blocks of scoria have been gathered and piled into heaps to make room for the crop. Speaking generally, a light porous soil was preferred, but where this was not available the land was improved by a layer of sand from the river-bed or from wherever it could be got. In Waikato the clay land was often treated in this manner with sand from the pumice plains, where the pits from which the supply was procured are still to be seen.

In choosing a site for the plantation other beside agricultural conditions had to be considered, especially in the case of a small or weak community. The crops being almost the only available personal property of the Maoris in the growing season, it was necessary to secure them as far as possible from the sudden raid of a *taua*, or war party, which might happen at any moment. This was generally done by scattering a number of small plots over a wide area, and placing them as far as possible in unlikely situations. In the case of a powerful tribe occupying a strong pa (fortified village) such precautions were unnecessary, and the cultivations were generally quite open and frequently of large extent.*

Cultivation.

In preparing a piece of land for cultivation much had to be done long before it was ready for planting, and, considering the nature of the tools available, the labour must have been almost incredible. The whole surface of the country was covered either with bush, fern, or tea-tree scrub, except, perhaps, on some of the river-flats, and even these had to be cleared of a rank growth of rushes, toetoe, flax-bushes, and other plants found in such places. The work was always done in the late autumn, when the weather was dry and breezy and the soil in a suitable condition for working. At this season also the fern-root (aruhe), an important article of food, was at its best. Fire was the principal agency for preliminary operations. For a bush-clearing (*waerenga*) a place was generally chosen at the edge of the forest,

* Cf. Colenso, *loc. cit.*

over which the fire had run some time before and had killed the standing trees. The branches and small stuff were broken down and piled around the larger trunks, and, where necessary, dry material was collected and carried in to assist the combustion. The small roots were dug up and thrown on the fires, and, where possible, the large stumps were undermined and prised out with a kind of gigantic spade worked as a lever by the united strength of several men.* This may seem rather a tedious way of clearing land, but a number of hands intelligently employed made light work, and on a dry, windy day the business proceeded merrily; and if some of the heavier masses of timber still proved refractory they were left to be dealt with at a future season, and so by degrees all obstacles to cultivation were removed.

In the case of clay lands, especially those on the river-flats, drainage was necessary, and, where possible, surface channels were made before the winter rains set in, as the prolonged exposure to water not only retarded the spring operations, but had the effect of "souring" the soil and making the work of cultivation more difficult. On the old cultivations the cleaning-out of these drains was the first thing to be attended to as the planting-time approached.

In breaking up new land the principal implement used was the *ko*, a kind of long-handled spade consisting of a pole of hard wood sharpened to a wedge-shaped point and furnished with a foot-rest or tread (*hamaruru*) lashed to one side with flax sinnets from about 12 in. to 18 in. from the bottom, according to the depth the land was to be dug. Both the foot-rest and the handle on the top of the shaft were often elaborately carved, as may be seen in the case of some excellent specimens in the Auckland Museum. Armed with this implement, a number of men formed in line a few feet apart across the plot that was to be operated on, and, keeping time to a song by their leader invoking a blessing on their labour, drove the *ko* into the ground so as to make a continuous cut about 1 ft. or 18 in. back from the face, according to the nature of the soil. This done, they used the implement as a lever and hove the whole sod over together, with a loud shout of *Huaia!* when they started afresh on another piece. Meanwhile the women and children followed up, breaking the clods with small wooden instruments of various patterns and clawing out the fern-root and rubbish with their fingers. The best of the fern-root was reserved for food and stacked up to dry, while the refuse, together with other useless fibrous matter, was thrown on to one of the heaps of burning timber.

It is not to be supposed that these processes were com-

* See Hamilton's "Maori Art," pt. iii.

pleted in regular sequence—*i.e.*, that the entire patch was cleared before the digging commenced, as would have to be done in preparing a piece of land for the plough. As a matter of fact, the several processes would often be going on simultaneously on different parts of the field, the smaller stumps and roots being taken out in the action of digging, while special gangs were dealing with the larger pieces, and the general crowd keeping the fires going all over the place. Allowing for the difference in the implements, practically the same system is pursued on a Maori *waerenga* at the present time.

The only object for the deep digging was to get rid of the roots and clear the land from the fern, which would otherwise shoot up and injure the growing crop. On a patch that had been previously cultivated it was sufficient to clean off the weeds and stir the surface for a couple of inches. In fact, it was an advantage to have a hard bottom, as where the tillage was too loose the roots of the kumara were inclined to run and the tubers to be small and of poor quality.

When the soil was worked up fine and made perfectly clean it was formed up into little round hills, called "*tupuke*," about 9 in. high and 20 in. to 24 in. in diameter, set quite close together. The party who undertook this operation commenced in one corner and worked back diagonally across the patch, each man having a row to himself; and as every hill was made to touch the two hills in the next row the whole plantation presented a fairly accurate quincunx pattern. Mr. Colenso, apparently, though perhaps unconsciously, quoting from Captain Cook's Journal, states that a line or cord was used to insure regularity.* No one, however, seems to have actually seen the line employed, and any old Maoris I have consulted are positive that it was never the custom to do so. The appearance of regularity arose from the uniformity of the size and shape of the hillocks and from the orderly manner in which the work was carried on, as well as from the neatness and finish which characterized it. This neat appearance is borne witness to by many old writers. Mr. J. L. Nicholas, who visited the country in 1814, describing a plantation in the Bay of Islands, says, "The nice precision that was observed in setting the plants and the careful exactness in clearing out the weeds, the neatness of the fences, with the convenience of the stiles and pathways, might all have done credit to the most careful cultivator in England."†

No manure, in the sense in which we understand the term,

* Trans. N.Z. Inst., xiii., art. i.
† "Voyage to New Zealand," vol. i., p. 252.

was ever used for the kumara. The very idea of such a thing would have been repulsive according to Maori ideas,* the only fertiliser employed being the sand already mentioned. This was carried up from the pits or river-beds in closely woven flax baskets, one basketful being placed on each hill. Men, women, and children joined in this laborious business, the slave and the *rangatira* working together.

PLANTING.

The planting usually commenced about October and extended more or less up to Christmas, according to the variation of the season, the state of the weather, the locality, and the condition of the soil. Various natural signs and portents assisted in determining the proper time for the work. Thus, when the kumarahou (*Pomaderris elliptica*), a small shrub with a sage-like leaf and yellow tufted blossom, which had been in bud all the winter, suddenly shot out into flower it was known that the season was approaching; and when a "mackerel sky"† showed an exact picture of a kumara-plot extending across the heavens the Maoris knew that the *atua* were busy at their planting above, and that they themselves ought to be doing the same below. As a matter of fact, the celestial phenomenon, portending as it does, according to the English farmer's proverb, a state of weather which is "neither wet nor dry," indicates an atmospheric condition exactly suited for starting the young plants.

Up to the time when the planting commenced everything was *noa*, or "common," but once the seed began to be handled until the crop was harvested the whole thing became *tapu*, or consecrated, including the ground, the plants, and even the workers so long as they were engaged in the cultivation. The *tapu* was invoked by the *tohunga* (priest) or the *kaumatua* (head chief), the two offices being often combined in the one person, by the performance of a *karakia* or religious service consisting of certain symbolical actions, accompanied by the chanting of an address to the *atua* (ancestral deity), its object being to ward off evil influences in the shape of injurious weather, insect pests, decay, &c., to protect the cultivation from intrusion, and generally to secure the blessing of heaven on the growing crop. Any breach of the *tapu* was a crime against the *atua*, and was punishable with death; and until it was removed by a second *karakia* by the *tohunga* it was unlawful for any "common" person to enter the plantation or even approach too closely to it under any circumstance whatever.

* Cf. Colenso, *loc. cit.*

† *Rangi kotingotingo*, literally "spotted sky."

While agreeing in essentials, there appears to have been great variety in the details of these *karakias*, especially in the invocations, every *tohunga* of standing having his own particular form of words, some of which were handed down from immemorial antiquity. Many of the ceremonies were very expressive, among which was one that used to be performed on the Island of Mokoia, in Lake Rotorua. It was described to me by Miss M. Bedggood, of Waimate North, who heard of it from some of the old natives living on the spot. On the day before the planting, when the seed kumaras were to be consecrated, the *tohunga* brought a small quantity in a basket made of dry raupo, shaped like a canoe, and presented it to the *matua atua* (ancestral god), of whom a little stone image stood in a wooden shrine on the island. Then, after the *waiata* (song) had been chanted, the vessel was set adrift on the lake, and was supposed to find its way to *Hawaiki*, whence the image was said to have been brought, and which was still the abode of the god.* By being thus made a sharer in the plantation it was believed that the *atua* would be reminded of the wants of his children and take the crop under his protection. A somewhat similar ceremony is related by Dr. Shortland in his "Maori Mythology" (p. 56).

It was considered absolutely essential that the planting of the entire plot, however large, should be completed in a single day, and in order to accomplish this a plan was often adopted similar to that of the Canadian "working-bee." In a large hapu, or division of a tribe living together, every principal man would have one or more plots of his own, and when one of these was to be planted his neighbours would come to assist at the work.

The business commenced with the consecration of the seed, which was done on the day previous to the planting, the seed consisting of the tubers which were too small to be eaten. If these were not sufficient, they were supplemented by the heads — the end containing the eyes — of the larger ones broken off for the purpose.

Early in the morning the workers, men and women, assembled. They were all of the *rangatira* class, no slave of either sex being allowed on the ground. After partaking of a plentiful meal provided by the owner they were made *tapu*, and henceforth they could eat no food until the work was completed, when the *tapu* was taken off. This, of course, had the effect of stimulating their exertions.

* Possibly this image may be identical with the *matua tonga* in the Grey collection, Auckland, which is stated to have come to New Zealand in the canoe "Arawa," and of which the later history does not appear to be known.

When all was ready several of the leading women of the hapu, taking each a basket of the seed, threw it right and left over the ground as they walked up and down chanting a *waiata*, the actual planting being done by the rest of the party. The sets were placed one in each hill, about 2 in. or 3 in. below the surface, with the head slightly raised and pointing towards the north, the approximate meridian being marked by conspicuous hilltops or other natural objects. It was believed that the sun, rising in summer in the south-east and passing round by the north to the south-west, had the effect of producing tubers on both sides of the plant.

As the business drew near completion the *kaumatua*, or head chief, chanted a long piece, partly as a stimulus to the workers and partly as a signal to the slaves to get ready the evening meal; and when the party left the field they were relieved of the *tapu* by a further ceremony conducted by the *tohunga*.

The *tapu*, however, remained on the plantation during the whole period of growth, during which, as before stated, it was unlawful for any one not under *tapu* to enter it, while even a *tapu* person was obliged to use the greatest circumspection. It was unlawful to enter the cultivation either from the south, the east, or the west. The south was the worst of all, as a person coming from that quarter might bring in the cold cutting wind that was so injurious to the *kumara*, while on the east or west the *wairua* (shadow) cast by the sun might spoil the crop. From the north, however, a person, if properly *tapu*, might enter, as it was thence that the warm breezes came that gave health and vigour to the plants.

CARE OF THE CROP.

The work of cleaning the growing crop was a comparatively light one in the old days, as the host of troublesome weeds that have accompanied European cultivation had not then made their appearance. One weeding was considered sufficient, and it was done in the dry summer weather by a party made *tapu* for the occasion, and armed with small wooden spades shaped something like a short paddle. Care, however, had to be taken to prevent the vines from rooting on the surface, as this was found to reduce the strength of the plant.

The laborious work of fencing against cattle and pigs was unnecessary before these animals were introduced by the early navigators. Captain Cook, however, noticed that the plantations were "fenced in, generally with reeds, which were placed so closely together that there was scarcely room for even a mouse to creep between." This was done to shelter the crop from the strong winds which blew in the early summer; and in exposed situations additional breakwinds, formed of fern

or tea-tree fronds stuck in the ground, were set up in lines across the plantation.* This system may be seen at the present day in the settlements along the Taranaki coast.

With the exception of the hotete, a caterpillar about 2½ in. to 3 in. long, the larva of a large moth, the kumara does not seem to have had many enemies amongst the insect world. Though rarely seen of late years, probably owing to the introduction of the pheasant, the starling, &c., in old times it was often very abundant, appearing suddenly in countless numbers and making complete havoc of the crop by stripping the leaves. Mr. Colenso states that the creature "was quite abhorred by the Maoris, who believed that it was rained down from heaven"; and he adds that the job of gathering the insects was greatly disliked. The work, however, had to be done; and they were carefully collected and burnt.†

The old native rat was a comparatively harmless little animal, but once its European congener was introduced its ravages soon taxed the utmost ingenuity of the Maori. The plantations had to be watched night and day, and all sorts of devices were employed to circumvent the marauders. Mr. Colenso describes two old men who had a network of flax-lines extending over the garden, at the ends of which bunches of mussel-shells were suspended, and, the whole being connected with a rope leading into the hut where they lived, a noise could be made from time to time sufficient to frighten away the thieves from gnawing the roots.†

Harvesting and Storing.

Long before the general crop was ready for lifting the plants were regularly laid under contribution. As this work demanded skill and experience rather than physical strength, it was usually left in the hands of the *kuias* (old women). With a small wooden spade they would gently loosen the earth and feel underground for the largest root. This was called *whakatau ki te ara* ("meeting [the crop] on the road"). The general crop was taken up about March or April, a dry sunshiny day being always chosen so as to avoid the danger of mouldiness. Should frost or prolonged heavy rains come on, however, the roots had to be dug at once to save them from rotting or second growth. The general harvest, or *hauhakenga*, as it was called, was the most important event of the year, all other operations being suspended until it was completed. It was naturally made

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* Compare "Excursion to New Zealand in 1841" (*Tasmanian Journal of Science*, vol. ii., p. 217).

† Trans N.Z. Inst., xiii., art. i.

the occasion of a *hakari*, or harvest festival, accompanied by religious rites; but of these I have been unable to learn any details.

The storing of the crop required the greatest care and judgment, as, in spite of every precaution, it was barely possible to preserve the stock until the next planting-time. Besides being a delicate article to handle, the kumara is susceptible to every change of weather. A single bruised or chafed tuber will soon rot and communicate the decay to those in contact with it, while a very short exposure to damp, or even to cold air, will quickly spoil the whole lot.

In constructing their storing-places the Maoris followed no uniform fixed pattern. As was usual with them, the idea they had in their minds was worked out subject to local conditions, and, as these varied more or less in every locality, it is not surprising to find a corresponding variety in their appliances.

The chief question being the exclusion of damp and the maintenance of a moderate and even temperature, the object was very simply attained in a dry porous soil by the *rua*. This was a circular pit sunk in the ground 5 ft. or 6 ft. deep and about the same in diameter, narrowing in at the top and closed by a trap-door made of a wooden slab. The kumara were handed down to a person standing in the middle, and were piled radially round the sides on a bed of soft fern or *Lycopodium* (waewaekoukou), a layer of the same material being placed between them and the wall. If sufficient accommodation were available only one pile was made, as they kept better if not packed in too large a mass. The enormous number of these *ruas* on the volcanic plains of Taranaki and elsewhere shows the extent of former plantations. They are called "Maori-holes" by the settlers; and before the country was thoroughly reclaimed they caused the loss of a good many horses and cattle, as, being frequently covered over with tangled fern, they were not generally discovered until a beast had fallen through.

In situations where the soil was not sufficiently porous to allow the *rua* to be self-drained it was built partly above ground, generally on the slope of a hill. The pit was dug 2 ft. or 3 ft. deep, and of an area proportionate to the quantity of kumara to be stored. An outfall drain was made from the bottom, and a surface channel round the top carried off the storm-water. A roof was made over the pit, the rafters being set in the ground at an angle of about 30 degrees, and covered with sticks and fern, on which was piled a thick layer of earth, and the whole was coated with fronds of nikau to preserve the earth from the wash of the rain. The entrance was made in the outfall drain, and was closed with a moveable wooden slab or sliding door.

Very frequently, however, the storing-place was entirely above ground. A small house was built with the walls about 4 ft. or 5 ft. high. These were framed of dressed slabs set vertically in the ground, with battens lashed on horizontally at intervals of a few inches, and covered over with two or three thicknesses of raupo so as to be completely airtight. Mangemange, a kind of climbing fern, or sheets of totara-bark protected the lower part of the walls, and against this the earth was thrown up from a ditch sunk below the floor-level, which acted as a drain for the building. The roof was framed in a similar manner to the walls, and also covered with raupo—sometimes with an inner sheeting of totara-bark—while an upper layer of toetoe-grass, secured by ropes of mangemange or wooden battens, preserved the raupo from the wet. A door was generally placed at each end, so that in order to prevent the wind from blowing in the house could always be entered to leeward; and the opening was made just large enough to allow a person to creep in on all-fours. This class of storehouse was always a conspicuous and picturesque object. They were often ornamented with elaborate carvings, inlaid with pawa-shell (*Haliotis*), and finished off with a *teko-teko* (grotesque wooden figure) set up at the apex of the roof.

Sometimes the storehouse was set up on legs 3 ft. or 4 ft. high, when it was called a *pataka*, and as the imported rat found its way into the settlements precaution had to be taken against its incursions by socketing the tops of the legs into heavy cross-pieces of timber hollowed out like sections of an inverted canoe. A very fine specimen of the *pataka* is to be seen in the Auckland Museum.

When only a small quantity of kumara had to be dealt with a very simple device, called the "*whakatoke*," was sometimes adopted. A shallow circular depression made in the ground was covered with a layer of long stalks of the common fern (*Pteris aquilina*), with the roots meeting at the centre and the heads radiating outwards. On this were piled about half a dozen kits (flax baskets) of kumara. The heads of the fern were then bent upwards and inwards so as to enclose the lot, and were tied together over the top. The whole was then covered with toetoe-grass, and a layer of earth was thrown up from a trench round the outside.

There were other modes of storing which were variations or adaptations of those mentioned, in all of which the Maoris were guided by local circumstances. Sometimes the pit was made inside a large shed, and sometimes it was driven horizontally into the face of a steep bank. Occasionally the tubers were placed on a raised platform (*whata*) and covered with mats and fronds of nikau, while in some rare instances the storehouse was built in the forked branches of a tree.*

* For illustrations of several forms of the kumara store, see Hamilton's "Maori Art."

"All these storehouses," remarks Mr. Colenso in the paper already frequently quoted, "were rigidly tabooed, as were also the few persons who were allowed to visit them for any purpose, all visits being formal and necessary." And he goes on to say that "the labour bestowed on them in those early times before the use of iron was immense, and that they were mostly renewed as to the reed-work every year."

COOKING.

Before the advent of Europeans the Maoris, being unacquainted with the use of metals, had no means of boiling in the ordinary sense. The act, however, was accomplished by means of the *haangi*, a contrivance common to the whole of the Polynesian race. It is still often used among the Maoris when a large quantity of food has to be cooked, and is generally known among European settlers as the "native oven," though the term "steaming-pit" would be a more exact description. To make a *haangi* a hole about 1 ft. or 18 in. deep is scooped in the ground, and of a diameter proportionate to the quantity of food to be treated. The hole is filled with short billets of wood set up on end, with cross-pieces above, on which are placed a number of stones about the size of a man's fist. The wood being kindled, the stones soon become red-hot, and fall to the bottom as the fuel is consumed. The embers are then removed and the stones spread out level. A little water poured from a height raises a jet of steam, which blows away the ashes, and the oven is ready. The kumara, after being carefully scraped and washed, together with any food that is to be cooked with them, as birds, fish, or other *kinaki* (relish), are piled on the stones and covered with soft fern. Water is now poured in and the oven is quickly spread over with several thicknesses of flax matting, after which a quantity of earth is shovelled over the top and sides and beaten hard with a spade until the steam no longer escapes. In about half an hour the cooking is completed, and the coverings are removed, great care being taken to prevent the earth getting on to the food, which is usually served up in little square baskets of green flax called *paaro*, a fresh lot being plaited for every meal.

This was the mode invariably adopted when the kumara was required for every-day consumption, a more elaborate plan being used when they were to be converted into a sweetmeat called *kao*. For this some of the small varieties were chosen. After being scraped and washed as before, they were dried in the sun for two or three days. They were then wrapped in the leaves of certain aromatic plants and packed in small kits before being laid on the stones. For the *kao* an extra hot oven was used, and no water was poured in, the only moisture

allowed being supplied from a layer of fern which had been previously wetted placed under and over the kumara, just sufficient to keep them from being scorched. They were allowed to cook for about twenty-four hours, and when taken out had a dry black appearance, with a sweet aromatic flavour. The *kao* would keep for any length of time if not exposed to damp, and was highly esteemed as a delicacy at a time when such delicacies were rare.

Such was the kumara in the old primitive times. It has long fallen from its high estate. As the Maoris became gradually possessed of the potato, maize, pumpkins, and marrows, and were able to obtain a supply of flour and beef and mutton, the relative importance of the kumara declined; and as the old beliefs gave way to the new ideas the *karakias* were no longer practised and the *tapu* vanished from the land. The neatly tended hand cultivation is practically a thing of the past, and the elaborate storehouses have fallen to ruin. The kumara is now generally put in with the plough, and if for want of proper attention the crop should turn out a failure "*Kei ahatia*" (what matter)? There is always the *kai-pakeha* (European food) to fall back upon.

Art. III.—*Foot-tracks of Captain Cook.*

By H. D. M. Haszard.

[*Read before the Auckland Institute, 6th October, 1902.*]

Plates I.–III.

I read with very great interest the paper printed in vol. xxxiii. of the "Transactions of the New Zealand Institute," entitled "On the Tracks of Captain Cook," by the late Professor E. E. Morris; and, having noticed his invitation for some one with local knowledge to fill in the gap caused through his not being able to visit Mercury Bay, I will endeavour to put together a few notes in regard to that place, though it is with some diffidence I follow after such an able writer; but now, alas! there is no chance of the subject being completed by him.

Some four years ago, whilst revising the trigonometrical survey of a portion of the Coromandel Peninsula, I was camped for several weeks about Mercury Bay, and in February of this year I was again in the same locality, so that I may claim a fair knowledge of the district.

After Cook's arrival at Poverty Bay, on the 9th October, 1769, he sailed as far south as Cape Turnagain, which he reached on the 16th October. He thence retraced his steps,

or rather his courses, northwards, calling in at several places along the coast; and on the 4th November was opposite the opening of a large bay, to which he subsequently gave the name of "Mercury." He states, "My reasons for putting in here were the hopes of discovering a good harbour and the desire I had of being in some convenient place to observe the transit of Mercury, which happens on the 9th instant, and will be wholly visible here if the day is clear."*

At the time of the "Endeavour's" visit there seems to have been a fairly large native population in and about the bay, but these people were nearly all exterminated some thirty years later in intertribal warfare, as will be related further on. The vessel remained eleven days in the bay, and, as a whole, the crew got on well with the natives, who showed Cook through some of their fortified pas, of which he has left very minute descriptions. During the stay some minor pilfering went on, and one native was shot by Lieutenant Gore. Captain Cook apparently, *à la* Gilbert and Sullivan, believed in "fitting the punishment to the crime," as his comment on this incident will show: "When they [natives in canoes] first came alongside they began to sell to our people some of their arms, and one man offered for sale a *haahou*—that is, a square piece of cloth such as they wear. Lieutenant Gore, who at this time was commanding officer, sent into the canoe a piece of cloth, which the man agreed to take in exchange for his; but as soon as he had got Mr. Gore's cloth in his possession he would not part with his own, but put off the canoe from alongside, and the natives then shook their paddles at the people in the ship. Upon this Mr. Gore fir'd a musquet at them, and, from what I can learn, kill'd the man who took the cloth; after this they soon went away. I have here inserted the account of this affair just as I had it from Mr. Gore, but I must own it did not meet with my approbation, because I thought the punishment a little too severe for the crime, and we had now been long enough acquainted with these people to know how to chastise trifling faults like this without taking away their lives."†

One of the most interesting events in connection with Cook's visit to the bay is his transit of Mercury observations, and I have been trying to locate the exact spot from which they were taken. Unfortunately, Cook has not described the position with his usual minuteness, and recent testimony is rather conflicting. The best description of the event which I have seen is in Admiral Wharton's edition of Cook's Journal, page 150, which reads as follows:—

* Wharton's edition Captain Cook's Journal, p. 148.
† *Loc. cit.*, p. 151.

"Wednesday, 8th, p.m.: Fresh breeze at N.N.W., and hazy, rainy weather; the remainder a gentle breeze at W.S.W. and clear weather. . . . At noon I observed the sun's meridian, zenith distance, by the astronomical quadrant, which gave the latitude 36° 47′ 43″ S.; this was in the river before mentioned, that lies within the south entrance of the bay.

"Thursday, 9th: Variable light breezes and clear weather. At 8 Mr. Green and I went on shore with our instruments to observe the transit of Mercury, which came on at 7h. 20′ 58″ apparent time, and was observed by Mr. Green only. I at this time was taking the sun's altitude, in order to ascertain the time. The egress was observed as follows:—

By Mr. Green	Internal contact at	12° 8′ 58″	afternoon.
	External "	12° 9′ 55″	
By myself	Internal "	12° 8′ 45″	
	External "	12° 9′ 43″	

Latitude observed at noon, 36° 48′ 28″. The mean of this and yesterday's observation gives 36° 48′ 5½″ S. the lat. of the place of observation, and the variation of the compass was at this time found to be 11° 9′ E."

Locally the place pointed out as the site of the observatory is on the promontory immediately above Shakespeare Cliff. Captain Gilbert Mair informs me that when he was there about 1862 an old Maori showed him a bare spot on this hill as the place where Captain Cook had his instruments. I have examined this spot, and I find that the surface soil has been removed for a few square yards, leaving the solid rock exposed; but whether this has been done by the hand of man or has been denuded by the wind and rain at this lapse of time it is impossible to say. Against this testimony Mr. Percy Smith, late Surveyor-General, to whom I wrote to see if he could throw any light on the subject, says that he was at Mercury Bay in the early "sixties," and the Maoris working on his party pointed out a position on the sandy flat near the mouth of Oyster River (Purangi) as the place where the observations were taken. However, owing to the dispersion of the original inhabitants, I think it very doubtful if any reliance can be placed on native testimony given ninety years after the event, as it would be at that date, and about a matter that would hardly be likely to impress itself upon the aboriginal mind in comparison with the many other incidents in connection with the "Endeavour's" visit. So that we are at last brought back to the log, and have to try what can be got from it and the surrounding circumstances.

We have a minor trig. station, marked "0," on the point above Shakespeare Cliff, a few yards to the west of the

alleged site of Cook's observatory, and I have computed its latitude and longitude from the meridian and perpendicular distances derived through the series of triangles from the stone pillar on Mount Eden, Auckland. The position of the latter was very accurately determined in connection with the American Transit of Venus Expedition of 1882, and the longitude tested by time-signals with Sydney. I make Station 0 = lat. 36° 49′ 37″ S., long. 175° 44′ 49″ E. Now, the mean of Captain Cook's observations is 36° 48′ 5½″ S., 175° 56′ E., and, applying them to the chart, it would place his position about a mile and three-quarters to the north and considerably to the east of Station 0; whereas if we accept the position at the mouth of Oyster River it would show a still greater discrepancy in the latitude. In regard to the longitude, it could not be expected that, with the appliances then used, it would be determined very accurately; in fact, it is a wonder that he got it to come in as close as he did.

From these considerations I am inclined to think the site above Shakespeare Cliff must have been the scene of his operations; and, indeed, from the position of his anchorage, it seems to me to be the most natural place an observer would select for such a purpose. It is situated on a little rounded knoll on the end of a plateau about 250 ft. above sea-level, with a clear view of the horizon, and is easily reached by a track leading up a gully from a small sandy bay immediately to the south of the cliff. Enclosed are a couple of photographs of this place, but, as the only plates I could get were of a brand I had never tried before, the exposure has not been too successful. I also enclose a map of the locality for reference to the places mentioned. (Plates I.–III.)

The following data, kindly supplied by Dr. C. Coleridge Farr, of the New Zealand Magnetic Observatory, of his recently determined variation of the compass at Mercury Bay, are of considerable interest, as showing the large increase of variation in the past hundred and thirty years—that is, if Captain Cook's reading of 11° 9′ E. can be accepted as reliable; but Cook himself mentions about ironsand being plentiful on the beach, and it is possible his observation may have been vitiated from that cause. The mean of several readings in various parts of the district with the little needle attached to my theodolite, and after allowing for convergence, is about 13° 45′; but I would not put it forth as of any weight compared with the sensitive instruments used by Dr. Farr.

MAGNETIC OBSERVATIONS AT THE TOWNSHIP OF WHITIANGA, MERCURY BAY, MARCH, 1901, BY DR. C. COLERIDGE FARR.

STATION A.—In a paddock just south of the township, in lat. 36° 50′ 15″ S. and long. 175° 44′ 13″ E. (9th March, 1901.)

Magnetic declination,	14° 22′ 19″	east at	10.02 a.m.
	14° 24′ 15″	„	11.08 a.m.
	14° 26′ 28″	„	12.15 p.m.
	14° 28′ 23″	„	1.55 p.m.
	14° 25′ 27″	„	4.49 p.m.

Horizontal magnetic force, 0·26737 c. g. s. units at 11 a.m.
Magnetic dip—Needle No. 1 = 61° 21′ 03″ at 2 p.m.
„ 2 = 61° 19′ 57″ at 3 p.m.
Mean dip = 61° 20′ 30″.

STATION B.—Just south of the Whitianga Cemetery, close to the ferry landing and about 3 chains from high-water mark; in lat. 36° 49′ 47″ S. and long. 175° 43′ 47″ E. (11th March, 1901.)

Magnetic declination,	15° 1′ 42″	east at	10.10 a.m.
	15° 4′ 17″	„	11.15 a.m.
	15° 6′ 50″	„	12.18 p.m.
	15° 8′ 49″	„	2.0 p.m.
	15° 6′ 35″	„	4.30 p.m.

Horizontal magnetic force, 0.26917 c. g. s. units at 11 a.m.
Magnetic dip—Needle No. 1 = 61° 16′ 26″ at 3 p.m.
„ 2 = 61° 15′ 1″ at 3 p.m.
Mean dip = 61° 15′ 44″.

Dr. Farr, in his letter to me, remarks, "The declination undisturbed should be about 14° 35′ E. There must therefore be magnetic rocks in the district affecting us, and, if so, it will be difficult to compare Cook's result with ours unless one knew the exact spot of the work and reoccupied it."

That Cook had a keen eye for the quality of the soil in the places he visited will be acknowledged by any one who has read his account of and seen the country to the south of the Whitianga River. It has a thin sandy soil overlying rhyolitic rocks, with patches here and there swept bare by the wind. The vegetation for the greater part consists of stunted fern and tea-tree, and altogether this part of the district has a most desolate appearance.

Cook's trip up the Whitianga, which he named "Mangrove River," is thus described: "The next day (Tuesday, the 10th) I went with two boats, accompanied with Mr. Banks and other gentlemen, to examine a large river that empties itself into the head of the bay. We rowed four or

five miles up, and could have gone much further if the weather had been favourable. It was here wider than at the mouth, and divided into many streams by small flat islands, which are covered with mangroves and overflowed at high water. From these trees exudes a viscous substance which very much resembles resin; we found it first in small lumps on the sea-beach, and now saw it sticking to the trees, by which we knew whence it came. We landed on the east side of the river, where we saw a tree upon which several shags had built their nests, and here, therefore, we determined to dine. Twenty of the shags were soon killed, and, being broiled upon the spot, afforded us an excellent meal."* This incident throws a strong side light on what must have been their ordinary fare when they could describe birds of that class as making "an excellent meal."

The two following extracts have even a stronger bearing on the same subject. During Cook's second voyage, on returning from the Antarctic seas he was very ill for some weeks, and he says, "When I began to recover, a favourite dog belonging to Mr. Forster fell a sacrifice to my tender stomach. We had no other fresh meat whatever on board, and I could eat of this flesh, as well as broth made of it, when I could taste nothing else."†

This is somewhat similar: "4th March, 1770.—This day the weather was more moderate than it had been for many days, and, being one of the inferior officers' birthday, it was celebrated by a peculiar kind of festival: a dog was killed that had been bred on board; the hindquarters were roasted and a pye was made of the forequarters, into the crust of which they put the fat, and of the viscera they made a haggis."‡

In these days of quick passages and fresh provisions it is hard to realise with what iron tenacity of purpose Cook and his men must have been endowed to battle along for month after month and year after year facing all the perils of unknown seas, thousands of miles away from any base, and living on such provisions as they must have had to put up with.

When I was at Whitianga the shags were still nesting in trees in the locality where Cook describes that his crew had such an excellent meal. The "viscous substance" mentioned was, of course, kauri-gum. There are extensive kauri forests on nearly all the branch streams which flow into the Whitianga, and the gum had, no doubt, been washed down

* Hawkesworth edition, vol. ii., "First Voyage," p. 338.
† Hawkesworth edition, vol. i., "Second Voyage," p. 275.
‡ Parkinson's Journal, 1st ed., 1773, p. 122.

and stuck in the roots of the mangroves, though it seems strange that a botanist of Banks's eminence should have fallen into error about its source.

Oysters were very plentiful at the time of Cook's visit, so much so that they got them by the boatload from the Purangi, and it was named "Oyster River" for that reason; but from some cause or other the oysters have almost completely disappeared. This seems the more strange as there is no large population at Mercury Bay to destroy them. Some of the settlers to whom I spoke on the matter attributed it to the sawdust thrown in the water from the kauri mills; but if that is so it could only apply to the Whitianga, as there are no mills on the Purangi.

In 1897 I rowed through the archway in Te Putaoparetauhinu, the small island on the north side of Mercury Bay, which is described by Cook; but at that time I did not know its history, and when last in the district had no opportunity to go over and take any photographs. There are, however, good pictures of it in both Hawkesworth and in Parkinson's Journal, though in the latter it is located in Queen Charlotte Sound. I expect this error has arisen owing to the confused state of the papers which Parkinson's editor had to work upon.

The large fort to the west of the island archway, which was also visited, is called Wharekaho. Cook gives a long description of this place, going into details of measurements of the ditches, palisading, fighting-stages, &c., and states, "The people seemed to be prepared against a siege, having laid up in store an immense quantity of fern-roots and a good many dried fish; but we did not see that they had any fresh water nearer than a brook which runs close under the foot of the hill, from which, I suppose, they can at times get water, tho' besieged, and keep it in gourds until they use it."*

These precautions did not avail the defenders, or perhaps they got more careless later on, as the following narrative, for which I am indebted to Captain Gilbert Mair, will show: "The numerous people spoken of by Captain Cook as inhabiting Mercury Bay district at the time of his visit were Ngatihei, the descendants of Hei, one of the chiefs who came in the 'Arawa' canoe. About the end of the eighteenth century, or commencement of the nineteenth, the most prominent warrior in these parts was Tuterangianini, who had led successful forays right down to Hawke's Bay. Being at enmity with Ngaiterangi, the Tauranga natives, one of their priests resorted to sorcery to bring about his death. He performed a ceremony called '*ahitapoa*' (fire to make boils)

* Wharton's edition, p. 154.

on an altar, with the result that Tuterangianini was stricken with boils, from which he never recovered. His tribe, Ngatitamatera, sent a war-party to attack Ngaiterangi, but finding the latter too powerful they returned without effecting anything. On reaching their own district they were taunted by the women, so they set off to Mercury Bay and attacked their own relatives, the unoffending Ngatihei, besieging them in the great pa Wharekaho, on the north-west end of Buffalo Beach. Being unable to take the place by assault, they cut off the water-supply and sat down before the fortress, intending to starve out the garrison. After several weeks (or months) had passed, and the Ngatihei were famine-stricken, the fort was taken by assault, and it is said a thousand of the unhappy captives were taken to the little beach below Peneamine's house and there slaughtered. A few escaped to the small fort on Te Putaoparetauhinu (Cook's archway), from which they could not be dislodged; but this numerous people was practically destroyed. Rahera and Erana Tanui, two women of rank living at Whitianga, are representatives of Ngatihei.

Tuterangianini

Te Rohu (no issue). Wharerangi

Haora Tupaea.

Haora Tupaea is a chief of Ngatitamatera, now living at Paeroa. He is about sixty-seven or seventy. The bodies of the slain Ngatihei were not eaten by the victors on account of their near relationship. Even at the present time the remains of hundreds of skeletons may be seen at Wharekaho, where the massacre occurred.

"Te Rohu was also a famous warrior, for he led the Thames tribes in an attack upon Ngaiterangi in 1828, taking Te Papa Pa and killing Koraurau, the principal chief, with three hundred of his people.

"The late Mr. Gilbert Mair, while in charge of the mission schooner 'Herald,' visited Te Papa and spent the night there two days before it was attacked."

Before leaving the bay Cook had the ship's name and the date cut on one of the trees near the watering-place, and, after displaying English colours, took formal possession of the land for His Majesty King George III. I think this spot must have been at one of the little rivulets which flow into the east side of the Purangi near its mouth, but the marked tree must long since have disappeared.

Mercury Bay is an ideal place for any one who is fond of boating and sketching to spend a summer holiday. It can be reached twice a week from Auckland by steamer, and there is

also a fair riding-road from Coromandel. The coast-line is broken up into innumerable picturesque headlands and islands, with many little bays of glistening white sand ensconced between, upon which the long ocean swell gently rises and falls. On the north side, especially when the pohutukawa is in bloom, the blaze of crimson fringing the beach makes a picture long to be remembered by any that have seen it. Other points of interest are the hot springs which come up in the sand, below high-water mark, a few miles from the south head of the bay. The wreck of H.M.S. "Buffalo" lies just to the north of the entrance of the Whitianga River. The vessel was wrecked in 1836, and in 1897 the ribs were just awash at dead low water, spring tides.

From Mercury Bay the "Endeavour" proceeded round Cape Colville, and, after sailing up the Hauraki Gulf, came to anchor a few miles from the present Thames Township. I had intended dealing shortly with Captain Cook's trip up the Thames River, but Mr. E. G. Moss, of Paeroa, who is also an enthusiastic admirer of our hero, tells me that he has been collecting data and photographs for some time with a view of writing a paper on that subject, so that I feel that I would be "jumping his claim" if I followed the foot-tracks of the great navigator any further.

Art. IV.—*Following the Tracks of Captain Cook.*

By Russell Duncan.

[*Read before the Hawke's Bay Philosophical Institute, 1st December 1902.*]

Plates IV.–VII.

Being greatly interested in the voyages of Captain Cook to New Zealand, and having visited some of the places on our shores touched at by him, I propose to tell you my impressions of these places, and to show on the screen photographs which I have taken. The localities which I have made it my pleasure to visit have been some of the actual landing-places of the great navigator, and my object in so doing was to see for myself how these scenes compare now with the descriptions given of them by Cook and his scientific companions.

You are no doubt well aware that Cook made three voyages from England to the Pacific Ocean. During these three voyages he visited New Zealand no less than five times, and landed at nine different places. It was on his first voyage, however, ranking as lieutenant in command of

the "Endeavour," that he paid most attention to New Zealand. He circumnavigated both Islands, and the chart of New Zealand which he then prepared was not added to by the Admiralty for nearly eighty years.

On this first voyage Lieutenant Cook landed at eight different places, and in the following order: Poverty Bay, Anaura Bay (called by him "Tegadoo"), Tolaga Bay, Mercury Bay, Thames Estuary, the Bay of Islands, Queen Charlotte Sound, and finally, before leaving, took his sea stock of water from the east side of D'Urville Island, at the entrance to Admiralty Bay. On the second voyage Captain Cook, in command of the "Resolution," was accompanied by the "Adventure," Captain Furneaux, but on the voyage out the two ships were separated by bad weather near the ice-pack, south of the Cape of Good Hope, where they were exploring. Cook, in the "Resolution," on coming up from the frozen south, made for the south part of New Zealand, and put into Dusky Bay, on the west coast of the South Island, which makes the ninth place visited. After recruiting there he proceeded to the rendezvous in Queen Charlotte Sound, and found the "Adventure" at anchor in Ship Cove, where she had been for six weeks. During the prosecution of his researches in the South Pacific Cook twice again visited Ship Cove, thus making three visits on this the second voyage. On his third and last voyage Cook, still in command of the "Resolution," with the "Discovery" as consort, visited the familiar Ship Cove once only.

We will now return to the first voyage. After discovering the east coast of New Zealand, Cook anchored in Poverty Bay on Sunday, the 8th October, 1769, and nowadays the intercolonial steamers, when anchored there, pretty nearly occupy his old berth. He landed the same afternoon on the east side of the Turanganui River. The ship's log says, "We landed abreast of the ship, and on the east side of the river." A low reef of rocks runs out here and renders landing easier. Afterwards the "Endeavour's" boats entered the river; but, as Cook says in his Journal, this was not always practicable, owing to the breakers on the bar. The appearance of the low land on the east side of the river has, of course, much altered, as the Gisborne breakwater has destroyed the old features, but what I suppose was the place of landing, some 200 yards to the eastward of the breakwater, under shelter of the reef, remains much the same as in October, 1769. The Ven. Archdeacon Williams (the present Bishop of Waiapu) has recorded a most interesting paper on the landing of Cook at this spot and what happened there, and it is published in vol. xxi. of the "Transactions of the New Zealand Institute." His early knowledge of Poverty Bay enables him

to describe the appearance of the place before the breakwater and freezing-works were built.

Cook, after remaining at anchor in Poverty Bay for three days, during which time he had several conflicts with the natives, and not obtaining supplies required, sailed south. He passed and named Table Cape and Portland Island, and entered Hawke's Bay. One night was spent at anchor in Hawke's Bay, between Portland Island and Long Point, within the Mahia Peninsula, but nobody landed. Sailing further into Hawke's Bay, he saw the large indentation of the land at Mahia, and then coasted round the bay, passing Wairoa, Mohaka, and Tangoio at a distance of two or three miles, until he arrived off a white bluff head, which is our Ahuriri Bluff. According to the bearings given, the position of the ship when off this white bluff head was about three-quarters of a mile north-west of where the Pania buoy is now moored.

On Cook's chart a channel is shown from the Inner Harbour to the sea near to Petane. The channel was less than one mile on the Napier side of the small Petane bridge, near which the manure-works are. All of you acquainted with the road to Petane will remember that here the beach is very low. The course of the old channel seen by Cook can be traced, as the north bank is well defined.

While off the white bluff head two boats from the "Endeavour" were manned ready to look for fresh water, but a number of canoes coming out to the ships, and the natives behaving in a hostile manner, Cook proceeded south. This was on the 15th October, 1769.

After passing and naming Cape Kidnappers, Bare Island, and Blackhead, he got as far south as abreast of Cape Turnagain. As the appearance of the country did not lead him to suppose he would come on any harbour he decided there to turn round and proceed north again in search of a watering-place. At length he reached Anaura Bay, which he called "Tegadoo," and the ship's boats were sent ashore for water. A heavy swell was running, and little water was taken off. The natives at Anaura explained that water could be easily got at the next bay south, which Cook afterwards called "Tolaga."

The romantic cove now known as "Cook's Cove" was the first spot in New Zealand where the voyagers had any luck at all. Fresh water and firewood were badly wanted. At Poverty Bay the water in the river was brackish and undrinkable, and, the natives being hostile, no wood was obtained. At Anaura, as I have just mentioned, the surf beat so high on the beach that little water was taken off, and impressions there were not of the best. At Tolaga a smooth landing was found in the

cove, and the necessities required were procurable. The natives were friendly, and the civilian scientists of the expedition were enabled to carry out their researches in this new pasture without molestation. Timing my visit to coincide with the month of the year it was visited by Cook, I was able to see the place much in the same garb as he did. I was also able to see the stream where the water was obtained in the same season of the year, and thereby to judge what difficulties there might have been.

In addition to the Journal of Cook, the writings of Sir Joseph Banks and the sketches and descriptions of Mr. Sydney Parkinson, available to us, help to make this spot the more interesting. I spent two days at Cook's Cove and on Sporing Island adjoining, and had with me manuscript copies of all the writings that I knew of relating to these places, so that I should not miss anything.

The "Endeavour" was not anchored in the cove, but in the roadstead of Tolaga Bay. The ship's log gives her position thus: "Anchored in 11 fathoms; fine sandy bottom; the N. point of the bay N. by E. and the S. point S.E., and the watering-place, which was in a small cove a little within the S. point of the bay, distant 1 mile."

The flat land at the head of the cove is now all very much overgrown with dense clumps of manuka and toetoe, and there is not a soul living there. At the time of Cook's visit the place was occupied by a good number of natives, and was under cultivation, for Cook speaks of the "little plantations of the natives lying dispersed up and down the country." Sir Joseph Banks, in his Journal, says, "Their plantations were now hardly finished, but so well was the ground tilled that I have seldom seen land better broken up. In them were planted sweet potatoes, cocos, and a plant of the cucumber kind, as we judged from the seed-leaves which just appeared above ground. The first of these were planted in small hills, some in rows, others in quincunx, all laid most regularly in line. The cocos were planted on flat land, and had not yet appeared above ground. The cucumbers were set in small hollows or ditches, much as in England. These plantations varied in size from 1 to 10 acres each. Each distinct patch was fenced in, generally with reeds placed close one by another so that a mouse could scarcely creep through." The plants seen by Banks would no doubt be the kumara, taro, and the gourd or calabash.

The main creek of water runs out on to the beach at the extreme head of the cove, and is a very small stream in October. As mentioned, I examined this place on the identical anniversary of Cook's visit, and found that the water was brackish for fully 50 yards from the beach. At low water the

greater part of the cove is dry, except where the stream runs over the white sand. At the present day, at low water, ships' boats could not get further up the cove than about a chain inside the low spit on the north point. The "Endeavour's" water-casks would need, therefore, to have been rolled up from the boats to the creek some 200 or 300 yards, and when filled rolled back to the boats—that is, of course, if the place be not changed. Old residents of Tolaga and natives who were born there told me that they have not noticed any alteration in the shores of the cove since they could remember. Cook says that "the water was good and the place pretty convenient," but he was not the kind of man to mention such small troubles as rolling barrels over some hundreds of yards of mud or boulders.

The firewood was, no doubt, cut just within the cove on the north point, as it is recorded in the log-book that there was "plenty of wood close to high-water mark." This north point is a more convenient place for boats to load at than the south. At the present day there is not a shrub growing on the south point, whereas bush is growing to within a few steps of high-water mark on the north. Nowadays dry drift-wood could be picked up above high-water mark in great quantity, and would be more useful for firing than green stuff. Cook, however, says, "The tree which we cut for firing was something like maple, and yielded a whitish gum." This remark leads us to conclude that green wood was cut.

A peculiarity of this part of the coast of New Zealand is the number of caves, caverns, and water-worn archways that exist, and these striking features were duly noted by our navigators. Most noticeable is the Isle of Arches, a long high rock washed through in a number of places with lofty and fanciful perforations. Standing seaward of this is a solitary rock, aptly named by Cook the "Cornstack." Referring to the log again we read: "At the entrance into the bay are two high rocks: one is high and round like a corn-stack, but the other is long, with holes through it like the arches of a bridge. Within these rocks is the cove where we cut wood and filled our water."

What is locally known as the "Hole in the Wall" is without doubt the most interesting sight in Cook's Cove. It is an archway leading from a valley in the cove through a hill to the sea-beach beyond. Sir Joseph Banks and other scientists from the "Endeavour," during their explorations, were very surprised on finding this wonderful freak of nature. Banks, in his Journal, says, "We saw also an extraordinary natural curiosity. In pursuing a valley bounded on each side by steep hills we suddenly saw a most noble arch or cavern through the face of a rock leading directly to the sea, so that

through it we had not only a view of the bay and hills on the other side, but an opportunity of imagining a ship or any other grand object opposite to it. It certainly was the most magnificent surprise I have ever met with; so much is pure nature superior to art in these cases. I have seen such places made by art, where from an inland view you were led through an arch 6 ft. wide and 7 ft. high to a prospect of the sea, but here was an arch 25 yards in length, 9 in breadth, and at least 15 in height." I roughly measured the archway, and found that the length and breadth as given by Banks is practically correct. I had no means of measuring the height, but think that Banks overestimates it. It is about 30 ft. high, or less. Sydney Parkinson, artist on the "Endeavour," in his Journal, gives a picture of this arch on page 99, of which I show a copy on the screen. In Parkinson's picture the place seems all clear of scrub. At the present day the bush and undergrowth is very thick, and it was impossible to obtain a position with the camera to include all of the opening. The creek running through the arch is not as Parkinson shows, but is full of large rocks and uneven boulders. Unfortunately, Parkinson did not live to return to England, but died of fever on the voyage Home after the "Endeavour" had sailed from Batavia. His diary and sketches were published by his brother, and it is likely that the picture was only half finished.

A good deal has been written in the "Transactions of the New Zealand Institute" about a place known as "Cook's Well," and I will now explain my views about it. There is a Maori tradition extant that Cook, or Tupaea, the Tahitian who accompanied him, cut a small hole in a rock near a spring of water in Cook's Cove, Tolaga Bay—I suppose for the purpose of making a basin to get a drink from. No record of this cutting is left by the commander or any of his people, as, of course, it would be an act of little moment to them. The Maori tradition, however, exists, and I am able to explain that the place shown by the natives for many years past, and known to Europeans as "Cook's Well," is not the place shown to Mr. J. S. Polack by the chief of the district in 1835. Every one who visits Cook's Cove is anxious to see Cook's Well, and the place shown is a small round hole in a steep rock face over which runs a trickle of spring water. This so-called well is some 30 yards up a steep hillside facing the north-west corner of the cove. A number of names and initials have been cut in the rock hereabout. Some one, too, has cut in deeply the name "COOK," and the figures "1778." I baled out the water from the hole and found that a more enterprising visitor had actually cut letters at the bottom. The

hole is round, and about 6 in. in diameter at the top and narrowing to the bottom, and the depth is about 12 in. Down the hillside, some 4 or 5 yards from the well, is a small cave over which the water trickles and drops down in front. The whole place is covered in by light scrub. This well is in an unlikely and out-of-the-way place, and its position does not agree with the description of the spot shown by the natives in 1835.

The first recorded account of a European visiting Cook's Cove for the sake of its historical associations is that of J. S. Polack, in 1835, and sixty-six years after our great navigator. Polack was conducted over the pathways of Cook by Kani-o-takirau, the chief of the district, who took pleasure in showing the place and telling the traditions. I will now explain about the place shown to Polack. Near the north point of the cove, and not many yards up the side of the hill, is a large cavern, not deep, but high and long. Over this cavern from the hill above a small spring drops down immediately in front into a watercourse which is shaded in by shrubbery. This is undoubtedly the cavern shown to Polack by the native chief, and in front of it is where Polack saw the cutting in the rock, which Kani told him was made by the order of Cook. Polack, in his book, "Travels and Adventures in New Zealand," vol. ii., page 130, tells us about this cavern and rock-cutting: "Kani requested me to accompany him next day to Opoutama, near the south entrance of the bay, where we should walk over the same ground and native paths that existed in the time of Cook, and which had been traversed by him. The following morning, at the beginning of the ebb, we went in the whaleboat, the chief, and the arch-priest (*tohunga-nui*), who was his brother-in-law, accompanying us." Polack goes on to describe the cove, and the plants and trees he saw there. Then he says, "The friendly Kani preceded me, and led the way through the devious native paths, which are never to be found in a straight line, even when the road over a plain best admits of it. The chief now wound his way up the side of the hill, followed by myself and the friends who accompanied us. We were arrested in our progress halfway by a cavern, which stopped our further progress. Its arch was remarkably high, but of little depth; it was similarly argillaceous to the caves we had seen below in the bay. Kani inquired if I felt gratified, adding, 'This, friend, is Tupia's cavern.' I learnt that in this cave the favourite interpreter of Cook slept with the natives. 'He was often in the habit of doing so during the heat of the day with his native friends, as is the wont of the New-Zealanders,' said my conductor. A few yards in front of the cave is a small hole that was dug in

the granite rock by order of Cook for receiving from a small spring the fluid that unceasingly flows into it." You will notice that Polack refers to a small hole dug in the granite rock in front of a large cavern, not above a small cave as shown nowadays.

To continue Polack's narrative: "The marks of the pick-axe are as visible at the present day as at the period it was excavated under Cook's eye. The water that overflowed this useful little memorial of our illustrious countryman was pellucid and very cold. The sun had not penetrated this sequestered spot for many years from the umbrageous kahikatoa and other trees that surround it. Around the surface of the cavern are many native delineations, executed with charcoal, of ships, canoes sailing, men and women, dogs and pigs, &c., drawn with tolerable accuracy. Above our reach, and evidently faded by time, was the representation of a ship and some boats, which were unanimously pointed out to me by all present as the productions of the faithful Tahitian follower of Cook (Tupia). This also had evidently been done by similar materials."

The back wall and roof of this cavern is of whitish silica, and favourable for making charcoal drawings upon as described by Polack. I noticed a drawing of two whales very well done. The delineation was well out of reach, and evidently done with a long charcoal-stick. This is further evidence that the cavern shown on the screen is the cavern of Tupaea, as the cave would not offer any advantages to a charcoal artist, being not 4 ft. high and dark inside. I am of opinion that since 1835 the natives have somehow lost the locality of the place to which their tradition refers, and that the chief Kani-o-takirau, who showed the place to Polack, was more likely to be correct than the natives of more recent years.

After searching in the watercourse immediately in front of this cavern and clearing away rubbish I found a square depression over which the water ran. This cavern would give shelter from the sun on an October afternoon to a large number of people, and if my opinion were asked I would say that the natives and probably Tupaea and the liberty men from the "Endeavour" occupied it as a sort of dress circle, from which to watch the work of wooding and watering going on below, and that the hole was cut in the rock to collect water for a clean drink. The depression in the rock is some 3 yards in front of the cavern, but I should not like to say that it was artificial, although after clearing the scum from off the bottom three small triangular holes were visible, as if made by a pick.

Sporing Island, the native name of which is Pourewa, runs

along parallel with the mainland, and its north point is a bluff head just without Cook's Cove. It has an area of about 80 acres, and is unoccupied. The island is named after Mr. Herman Sporing, one of Sir Joseph Banks's retinue on board the "Endeavour." The channel between the island and the mainland is narrow, and shallow at low water. Our voyagers visited this island, and Banks saw here the largest war-canoe he met with on his voyage to New Zealand. The dimensions of the canoe were: Length, 68½ ft.; breadth, 5 ft.; and depth, 3 ft. 6 in. He also saw here a large uncompleted building, with side posts carved, as he says, "in a masterly style, with spirals and distorted human faces." There is a most extraordinary subterranean cavern here, leading from the sea on the east side of the island to near its centre, where it opens out to daylight in a large crater-like abyss some 50 ft. deep. At low tide the natives say that it is possible to walk and crawl out to the coast from the bottom of this crater. At high tide the water rushes in. Cook's people could not have seen this place, as, being so remarkable, they would surely have mentioned it if they had. Polack records that he did not visit Sporing Island, but was told about the subterranean passage by the natives.

Cook sailed from Tolaga Bay on the 29th October, 1769, having been at anchor there for six days, during which time 70 tons of water was shipped and sufficient firewood obtained. He never revisited it, but Captain Furneaux, in the "Adventure," spent seven days there—from the 9th to the 16th November, 1773—getting wood and water. The cove can never be of use as a harbour as it is too shallow, and is exposed to the north-east and east winds.

Before concluding about Cook's Cove, Tolaga Bay, I must say that I think the Government should be prevailed upon to acquire the title to the cove and let the place remain in its natural state, as has been done at Ship Cove, Queen Charlotte Sound. I do not mean to infer that the Government should set aside all places in New Zealand visited by Cook; but this cove above all others has so many natural as well as historical attractions that I am sure the people of this colony and visitors in days to come would be pleased to see it kept in its natural state.

After leaving Tolaga the "Endeavour" called at Mercury Bay, Thames Estuary, and Bay of Islands, and, rounding the North Cape, sailed down the west coast of the North Island and anchored in Ship Cove, Queen Charlotte Sound, which is at the north end of the South Island.

At the time of my visit to Queen Charlotte Sound last Easter I was unaware of Cook's chart of this place which is to be found in Hawkesworth's edition of the Voyages, but had

with me the modern one as surveyed by Captain Stokes and Commander Drury of the "Acheron" and "Pandora" in 1849 and 1850, and in present use. Some names of places given by Cook, and appearing on the old chart which he compiled on his first voyage, have been altered. Thus, Long Point has been renamed Clarke Point, West Bay has been changed to Endeavour Inlet, and Shag Cove to Resolution Bay. The following titles also appear on the modern chart: Mount Furneaux, Edgecumbe Point, Pickersgill Island, and Fannin Bay. These are all named after Cook's officers, but whether this was done by Captain Stokes I do not know. In his second and third voyages, as far as I can investigate, Cook has left no record of having so named these places.

On arrival at Picton I hired a handy little oil-launch in preference to a sailing-boat, as I had only three days to spare. After proceeding about sixteen miles down the Sound we were on the look-out for a sheltered bay in which to pitch camp. We sighted some tents in a picturesque cove, where Mr. James Ratcliffe is settling and building a house. He very kindly offered to accommodate our party in his tents, and very comfortable he made us.

Sir Joseph Banks speaks of the "melodious wild music of the birds" in the early mornings at Queen Charlotte Sound. He says that their notes resembled small bells, but with the most tunable silver sound imaginable. It is generally supposed that the korimako, or bell-bird, is pretty well extinct. However, during the early morning at this camp I was agreeably surprised at hearing plenty of them.

In the morning we were under way betimes, steering straight across the Sound for Ship Cove. I believe that almost every English boy has read Cook's Voyages, and must have formed a picture in his mind of the haven in Queen Charlotte Sound that Cook so often, and I may say so lovingly, visited. A kind of intuition must have prompted this wonderful seaman in the first instance to find such a perfect harbour. Ship Cove, I should fancy, has almost the same appearance at the present day as when the "Endeavour" dropped anchor there on the 16th January, 1770, as the whole place is bush-clad down to the water's edge. During Cook's later visits the natives in great numbers were attracted by the presence of the ships. We read that they cleared the flat land to make room for their habitations until all the available space was taken up by them.

Several small streams percolate through the beach to the sea, but the main stream which runs into the sea at the head of the cove is a splendid rill of water. The filling of water-casks here would be an easy matter in comparison with Tolaga. It is rather hard to judge how much flat land there

really is in this cove. I explored inland for some distance, but, finding that fighting one's way through the thick undergrowth was not conducive to reflections about Captain Cook, I soon returned to the beach. A few English fruit-trees and some willow-trees are growing wild, commingled with the native scrub, no doubt planted in days gone by by some whaler who had appropriated the cove for a time.

In addition to having anchors down, Cook held his ship in position by hawsers fastened to the trees on shore, and during westerly gales we read that occasionally these hawsers parted. The ocean swell does not reach this cove, and the breaking of a few ropes is easily understood when one realises how hard it sometimes blows here. Westerly winds would be off shore.

It is worthy of note that the "Tory," the first ship of the New Zealand Company, bringing from England surveyors and pioneers, knowing of no other harbour in this part of New Zealand, made for Ship Cove, anchoring there in August, 1839. From here the "Tory" sailed into the channel named after her, and, getting a whaler as pilot, proceeded to look for a site for a settlement. Where the City of Wellington now stands was the place chosen.

Captain Cook, during his three voyages, occupied Ship Cove for exactly a hundred days. On the two occasions when Captain Furneaux, in the "Adventure," was separated from Cook he occupied it alone altogether sixty-five days.

Cannibal Cove is the next bay to the north of Ship Cove, and is where Cook and his boat's crew realised the grim fact that the New-Zealanders were cannibals. The place is occupied by a settler now, and is under cultivation, and the native bush has been made to give place to grass.

The most historic Motuara Island lies abreast of Ship Cove, and about two miles from it. On the highest part of the island is the spot where Lieutenant Cook erected a post and took possession of New Zealand in the name and for the use of His Majesty King George III. This ceremony took place on the 31st January, 1770. A bottle of wine was drunk, and the inlet dignified with the name of Queen Charlotte Sound. A native chief who had accompanied Cook to the top of the island was very pleased to receive the empty bottle as a present. From the shape of the surface of the ground at this spot, I could see that a considerable amount of digging has taken place, but whether it is as Cook left it I cannot say. Somebody may have been digging since, looking for relics. It is hardly necessary to say that the post has rotted away long ago.

Beyond the south-west end of Motuara Island, and only separated from it by a few feet, stands an isolated rocky

ridge, and this was where Cook found a strongly fortified pa on his visit in the "Endeavour." On the second voyage it was found that the natives had abandoned it. Captain Furneaux, of the "Adventure," who arrived here on that voyage six weeks before Cook in the "Resolution," used it upon which to set up his astronomical observatory. We read that the people from the "Adventure" stationed here were much troubled by fleas from the deserted habitations of the natives. Rats were also here in immense numbers, and the sailors sought to minimise the nuisance by putting large jars in the ground, into which the rats fell during the night. I found the top of this ridge entirely overgrown with thick scrub and very uneven, and during a short exploration was unable to notice any signs of ancient fortifications. Night coming on, we boarded the launch and made the best of our way to camp.

I had planned that my third day in the Sound should be spent searching for Grass Cove, the scene of the massacre of a boat's crew belonging to the "Adventure," as from what I had read in the Transactions there seemed a doubt as to where it was.

At a period in Cook's second voyage the "Adventure," Captain Furneaux, had become separated from the "Resolution," and was at anchor in Ship Cove alone. On the 17th December, 1773, Captain Furneaux sent two officers—Mr. Rowe and Mr. Woodhouse—and eight of the crew in a boat across the Sound to gather wild greens for the ship's company. As they failed to return to the ship at night the captain became very anxious, and in the morning despatched Mr. Burney, the second lieutenant, in search. Mr. Burney was a very precise officer, and has left a fairly detailed account of his day's search, which resulted in the finding of some mangled remains of his shipmates at Grass Cove. Mr. Burney's report is in the form of a letter to his commander, and is copied in the ship's log-book. I had with me a copy of this report.

I had made inquiries at Picton as to the whereabouts of Grass Cove, but nobody knew the name. One old gentleman told me it was understood that the massacre happened at Cabbage Bay. Last Christmas Mr. A. H. Turnbull, of Wellington, an enthusiastic searcher into early New Zealand history, had made a cruise to the Sounds in his yacht. He was possessed of Hawkesworth's edition of "Cook's Voyages," in which was the chart of the Sound, and on which Grass Cove is marked. I had with me photographs which he had taken in the Sounds, and which he had kindly sent me, and Grass Cove was one of them; but I had not asked him where it was, thinking that I would have no diffi-

culty in getting information at Picton. Round the camp-fire on our first night we tried to fix it. Mr. Ratcliffe, after reading Lieutenant Burney's report, affirmed that the place described could not be very far from where we were, and, on opening the packet of photographs, our surprise was great to find that we were actually at Grass Cove, and sitting but a few yards from where the unfortunate men were killed. The feeling was rather awesome, notwithstanding the 128 years that had elapsed, the occurrence and details being vividly before our minds. There was no doubt about it, for the place tallied with what Lieutenant Burney described.

Now that Grass Cove had been so easily found, I thought that our third day could not be better spent than in trying to go over the course taken by Burney in his search for his missing shipmates. Therefore the following morning we were up soon after the bell-birds and under way, armed with the modern chart and the lieutenant's old report. The instructions given to Mr. Burney by Captain Furneaux were to "look well into East Bay, and if no sign of the boat there then to proceed to Grass Cove." Burney's course across the Sound we knew, for he mentions passing Long Island and rounding Long Point. We rightly concluded that the Clarke Point on the modern chart was the Long Point of Cook. Mr. Burney was in charge of a boat heavily laden with a good number of men, with their muskets and ammunition and three days' provisions, and his pace through the water would not be as fast as our modern oil-launch. Some rough calculation was therefore necessary to fit our time and distances in with his. We found that Mr. Burney explored into what is now called Gilbert Bay and along the north shore of East Bay, and, not finding any traces of the missing boat there, crossed over the bay to the east shore. We got on his tracks on the east side, where he says there was a native settlement. Although no natives live there now, and the place is all overgrown, Mr. Ratcliffe, who was with us, knew the spot to be where a pa had once been.

On a small beach adjoining to Grass Cove Burney found the first evidence that a massacre had taken place, for some baskets had just been brought there by a canoe. In these baskets were cooked human flesh and fern-root, also the hand of a white man with "TH" tattooed upon it. From the site of the old pa to this small beach took us twenty-two minutes. Burney records that his time was within an hour. Mr. Burney's report says, "I launched the canoe with intent to destroy her, but, seeing a great smoke ascending over the nearest hill, I got all the people into the boat and made what haste I could to be with them before sunset. On opening the

next bay, which was Grass Cove, we saw four canoes, one single and three double ones, and a great many people on the beach, who on our approach retreated to a small hill within a ship's length of the water-side, where they stood talking to us." The small hill alluded to by Mr. Burney rises up from the beach about the middle of the cove. Captain Cook visited this place three years afterwards, on his third voyage, and tells what he could find out about the cause of the calamity. He also says, "Pedro and his companions, besides relating the history of the massacre, made us acquainted with the very spot that was the scene of it. It is at the corner of the cove on the right hand." This means, I feel sure, the right-hand corner of the cove looking towards it from seawards.

Grass Cove is known to the people of the Sound as Nott's Bay. Its Maori name is Otanerua.

Professor Morris, in vol. xxxiii. of the Transactions, page 501, falls into an error about the locality of this massacre, and records that it happened at a place which he calls Adventure Bay. There is no Adventure Bay on either Cook's chart or the modern one. The bay alluded to, of which Professor Morris says the two headlands are Edgecumbe Point and Marine Point, is called on the modern chart Endeavour Inlet and on Cook's old chart West Bay.

Art. V.—*Food Products of Tuhoeland: being Notes on the Food-supplies of a Non-agricultural Tribe of the Natives of New Zealand; together with some Account of various Customs, Superstitions, &c., pertaininy to Foods.*

By Elsdon Best.

[*Read before the Auckland Institute, 6th October, 1902.*]

It will probably surprise many to learn that a non-agricultural tribe of Maoris obtained in the North Island of New Zealand to within comparatively late times. It was in this wise: Before their conquest of the Ruatoki and Waimana districts the Tuhoe or Urewera Tribe possessed no lands on which the *kumara*, *taro*, or *hue* might be cultivated, their country consisting of remarkably rugged and high-lying ranges, with narrow gullies between them, and with nothing in the way of flat land or alluvial soil. The three cultivated food plants enumerated above, possessed by the Maori in pre-European days, will not thrive in this region, and hence the denizens of Tuhoeland, the Children of the Mist, were compelled to subsist upon the products of forest and stream. Of course, when the potato was acquired from the early European voyagers to these shores, then it was found that the new

tuber flourished exceeding well in Tuhoeland, and this new food product must have been an immense boon to these bushmen.

Until the introduction of the potato there were practically no clearings in the great forest which covers this rugged district. As the people had nothing to cultivate, and, moreover, as all their food-supplies were obtained from the forest, it behoved them to interfere with that forest as little as possible. The natives lived in small, scattered settlements, each consisting of a few huts situated in a small clearing. Also in those days but little fern-root was obtainable within the boundaries of the Tuhoe Tribe, and it was not until they occupied the Ruatoki, Waimana, Te Whaiti, and Waikare-moana districts that they came into the possession of lands producing the *aruhe*, or edible fern-root.

According to Maori belief, the Earth Mother it is who provides her descendants with food, which she does out of affection for her offspring, who were scattered afar across the world in the days of the gods. One division of the Tuhoe people—viz., Ngai-Tama, of Te Waimana—carried their respect for the Earth Mother so far as never to bury their dead in the ground, but always placed the bodies up in trees. It was not right, according to their ideas, to put the bodies underground, as it is the earth which produces food for man.

Food ever occupies a very important position in the native mind. Their thoughts, conversation, proverbial sayings, and stories deal frequently with this subject. This probably springs from the fact that food was difficult to procure in the old days, and called for almost continuous effort in one way or another, hence such work occupied their minds almost as much as their time. Each month, as it came round, in all seasons, had its task for the bushmen, birds or rats to be caught or certain berries to be gathered and preserved.

It is not my intention in this paper to describe the innumerable methods of taking birds and rats (*kiore*), with the rites, superstitions, &c., pertaining thereto, which obtained here in former times. The task is too lengthy for the time at my disposal now; and, moreover, I hope to include such in a paper on "Forest Lore and Woodcraft," to be prepared and forwarded in the future.

As observed, the procuring of food occupied much of the time, skill, and thoughts of the Maori. The man who was diligent in procuring food was thought much of, while other accomplishments would often appear to have taken second place. I chanced to remark one day that Piki, of Tuhoe, must have been a great composer, so many songs being attributed to him. An old native observed, "Yes; he com-

posed a great many songs, but I think that means that he was a very lazy man."

Times of scarcity of food were by no means rare. These would usually occur before the bird-taking season in the interior of the island, and often on the coast when the sea was too rough to permit of fishing-canoes going forth. At such a time natives would exert themselves as little as possible, and would spend most of their time in lying down. They would rise late, take an enormous drink of water, and then lie down again. Some time after they would partake of the one scanty meal of the day, after which they would again lie down. They drank great quantities of water at such times.

Usually the old-time Maori would have two meals a day. They would rise early and proceed to the work of the day, in the cultivations or elsewhere. Having worked several hours, they would partake of the first meal, prepared by the women, at nine or ten o'clock. They would then recommence work and proceed until quitting-time, which was usually early. After this the second meal was eaten. In returning to the protecting fort for the night the women would bear on their backs great bundles of firewood or of food.

When the Rev. Mr. Colenso visited Waikare-moana in December, 1841, he found the natives of that place had scarcely any food at the time, and were living upon roots and herbs and a few potatoes which they had left from the previous year.

The Maori is ever closely in touch with nature, owing not only to their ever searching for the products of forest, plain, and waters, but also to the fact of their genius for personification and the belief that the human race, animals, fish, birds, trees, &c., are all sprung from a common source, are all descendants of the Sky Father and the Earth Mother. We shall note some singular results of this belief in the present and also in future papers.

The Maori larder was sadly deficient in flesh foods, and this may possibly have had something to do with their cannibalism, for they were undoubtedly fond of human flesh as a food, with the exception of those who were *koto*—*i.e.*, who had a feeling of repugnance towards that unnatural diet.

The domestic dog (*kuri*) was not numerous enough to form an important item in the native bill-of-fare, but its flesh was highly esteemed. This dish, however, only appeared on important occasions, as at a feast, or when prepared for a distinguished visitor. The hindquarters of the *kuri* are said to have been the best eating. Its flesh was sometimes used as an *o matenga*, or food for the death journey, on account of its delicacy from a Maori point of

view. When a person was near unto death a special food would be prepared as a last meal for the dying person. Earthworms (*toke*) were a favourite article for this purpose, and it is said that the sweet flavour (*tawara*) of that prized food would be detected on the palate of the eater for two days after the meal.

Apparently the *kuri*, or at least one breed thereof, that known as *ruarangi*, was possessed by the first Maori inhabitants of this land. Judging from the way in which this animal is spoken of in the local traditions, it appears probable that there were two breeds or varieties of the domesticated dog here in former times.

The flesh of the *kiore*, or native rat, was highly prized by the Maori, and formed one of the principal food-supplies of Tuhoeland. This little creature was very numerous in this district formerly, more especially on the high-lying ranges, where it fed on the beech mast, and was trapped in great numbers. It disappeared about the early "fifties." The expression "*tau niho roa*" was applied to a season when the *kiore* were particularly numerous, and hence bold in stealing from the food-stores of the natives. The flesh of the rat was preserved for future use in the same manner that birds were—viz., by taking out the bones and placing the flesh in a vessel, which was then filled up with melted fat, which preserved the contents. Rats and birds preserved in this manner are termed *huahua*. Old natives say that the bones of the rat were pulled out quite easily, that the flesh did not appear to adhere to them. When cooked for immediate consumption the rat was wrapped in leaves of the fern termed *petipeti* and placed in the *hapi*, or steam-oven. Such a wrapper or envelope for birds or fish is termed *kopaki* or *poutaka*. The rat was cooked without being skinned. They were caught in traps and pits; which we will describe later on. It is said that two kinds of rats obtained here, the *matapo*, a black variety, and the *tokoroa*, a grey one.

An old myth of the Bay of Plenty tribes tells us that Pani was the (mythical) mother of the *kumara*, and that one Hinemataiti, a younger sister of Pani, was the origin of the rat.

Regarding the cannibalism of the Maori, human flesh was not only eaten after a battle, but also it was preserved for future use as *huahua*, in the manner described above. When rations fell short or some special food was required for a feast or to place before a guest a slave would be very likely knocked on the head, and his body consigned to the oven. Again, special raids were often made for the purpose of procuring human flesh or to capture a person to be slain, cooked, and eaten, in order to give prestige to certain rites of old, such as the opening of a new house, the tattooing of a chief's

daughter, or the performance of the *tua* rite over a new-born child.

The diet of the Tuhoe Tribe was ever largely vegetable, and we will commence with those plants or trees of which the roots or subterranean parts were eaten.

Aruhe (Fern-root).

This is the root of *Pteris aquilina* var. *esculenta,* the plant being known as *rarauhe*, and the young shoots or fronds thereof as *mokehu*. It is the common fern seen almost everywhere in unimproved open country.

Among various peoples, more especially those living in the more primitive culture stages, a feeling akin to reverence is evinced for staple foods. Mahomet said to the Arabs, "Honour the date palm, for it is your mother." In like manner the Maori should honour the fern-root, for it has ever been a most important article of food in these isles, more especially among those tribes who had no access to the coast, and with whom the *kumara* and *taro* did not flourish or thrive without much labour and care.

However, the Maori has honoured the *aruhe* by assigning to it a celestial origin, thus placing it on a level with man: for the origin, personification, or parent of the *aruhe* is Haumia, one of the offspring of Rangi and Papa, the Sky Parent and the Earth Mother, and brother to Rongo, the origin of the *kumara,* or sweet potato. For Maori mythology teems with such allegories or personifications, and with many singular metaphorical terms.

Hence fern-root is often termed the *peka o Haumia*, and was often spoken of as the salvation of man, it being a great and ever-obtainable stand-by when other food-supplies ran short. An old native once said to me, "Let me explain to you. The ancestor who ever provides for his descendants is Haumia. The food he provides for man is seen on hill and plain and in the valleys between. That is the good work of Haumia, the supplying of his descendants with food. For Haumia is the origin of the *mokehu* (fern), and the children of the *mokehu* are the *waeroa* (mosquitos), who, with their companions the *namu* (sandfly), ever wage war against man. And *haumia-roa* (a term for fern-root) was the principal food of the ancient people of this land before the *kumara* and *taro* were brought hither from Hawaiki."

This Haumia must not be confused with his descendant Haumia-nui, who was a female, and who married Tiwakawaka, the earliest human resident in Aotearoa (New Zealand) of whom tradition tells us. We give below the descent of Haumia from Rangi and Papa:—

Rangi = Papa
|
Tane = Hine-rauamoa
|

- Rongo (origin of kumara a of peacemaking).
- Hine-te-iwaiwa (origin of death; beca goddess of Hades).
- Tangaroa (the Maori Neptune
- Tu god (
- Tawhirimatea (personification of gales)
- Haumia (origin of *ar*
- Ioio-whenua (personification peace).
- Pu-te-hue (gin of *hue* gourd).

Haumia is spoken of in an allegorical manner as being the bones and flesh of Papa (the earth). "Papa, the Earth Mother, said to her offspring, 'I will provide sustenance for you.' Hence the Maori people dig into the earth to procure fern-root from their ancient mother. Just think of man. A child is born of the female parent, and is fed on the milk of the mother and attains manhood. Even so is man fed by his ancient mother, the earth."

The natives recognise different varieties of fern-root, each having its name. We give here a list of such names obtained in this district :—

Motuhanga, said to be the best variety ;
Mātā ;
Manehu, said to be good, a mealy variety ;
Paka, a good variety ;
Kaka-nui, inferior, but occasionally eaten ;
Koata,* very inferior ; it is not eaten ;

(generic term, *aruhe*.)

The term *tuakura* is applied to inferior fern-root, which is brown or reddish in appearance when broken. The prized varieties are thick roots, containing very few of the black fibres (*kăkă*), and which are brittle when broken, exposing a fine white interior. A cake made of the pounded meal of the fern-root is termed *komeke*.

The principal implement used for digging fern-root was the *kaheru*, which was made from a hard wood, as *maire* or *mapara*, and was from 2 ft. to 3 ft. in length. One end thereof was sharp and flattened, about 4 in. in width ; the other end, being the hand-grip, was round (*topuku*). Another implement sometimes used for the purpose was the *rapa maire*, a sort of rude wooden spade. The *ko*, or planting-tool, was also sometimes used to dig fern-root.

* Possibly *koata* refers to the young shoots of fern.

When engaged in digging for fern-root a *karakia*, or charm, known as a *tewha* was recited in order that a plentiful supply might be obtained. We append specimens of these charms:—

Ko rua uri, ko rua tea
Ko rua i te whatiwhati
Ko rua i te monamona
Te peka o tu aruhe
Te homai nei
Te whakawhiwhia mai
Te whakarawea mai
Ki te mata o tenei kaheru
Oi whiwhia, oi rawea
Hato whano
Tu mai te toki
Haumi—e!

The following is a *taumaha*, a form of charm used for much the same purpose as we say grace before meals. Such invocations were much used in ceremonies pertaining to the first fruits of birds, fish, crops, &c.

Taumaha te peka o tu aruhe
Te homai nei
Te whakawhiwhia mai
Te whakarawea mai
Ki te mata o tenei ko
I whiwhia, i rawea
Homai taku aruhe.

Prior to the repeating of the above the first root dug was roasted at a sacred fire by the priest officiating, who would probably eat the roasted meal of the *aruhe* himself, he being the medium of the gods.

A place where fern-root was dug was termed a *tawaha aruhe* or *karinga aruhe*. The fern was burned off these places about every third year, for two reasons—to render the roots white, and to prevent the fern being smothered or overgrown (*kaikairakau*) by scrub, such as *manuka*, *mako*, &c. This burning was done at the time when the *hinau* and *whakou* * were in bloom. If the burning was left until the blooming of the *rata* and the *korukoru*,† then the fern-root would become brownish (*mawera*) in appearance, and be unfit to eat. Fern-root was dug when the *mokehu*, or young growth of fern, had attained its full height—that is to say, in the early summer. But in times of scarcity it would be dug at any time.

The fern-root when dug was thrown into heaps (*koputu*), and afterwards carried to the village and stacked on a sort of stage termed a *titara aruhe*, where it was left exposed to wind and rain until "cured," or dried, when it was packed

* *Whakou*: The flower of the *tawari* tree is so termed in Tuhoeland.

† *Korukoru*: Name of the *pirinoa*, a parasitical plant, when in flower. It usually grows on *tawai* trees.

into baskets (*kete*) in layers, this latter process being known as *whakamātā*. These baskets are then stored in the cooking-huts or food-stores. When the cooked article is required the fern-root is roasted at a fire and the outside part scraped off, and the root is then beaten and pounded with a short club 10 in. or 11 in. in length.* When pounded the black stringy fibres are taken out and the root again pounded, after which the mealy portion is eaten. Or the meal is cleaned and pressed into cakes termed *komeke*, which are round and about 8 in. in length. These were again roasted at a fire, which prevented them from crumbling and formed them into a compact mass. These cakes or rolls were sometimes steeped in the juice of the berries of the *tutu* shrub, of which more anon. This latter was quite a treat to the neolithic gourmands. *Komeke aruhe* was the chief food carried by war parties when on the trail of Tu. It is said to be a very sustaining food.

When fern-root was required to be kept for some time it was placed under water in some convenient pool, where it would be kept for possibly a year.

Fern-root grounds were jealously guarded in former times, and woe betide the outsider who attempted to dig roots there. Tapuha, of Ngati-Apa, was slain by Te Arawa at Pekepeke, on the Kaingaroa Plains, for the above offence; while Ngati-Hape slew Te Rakau, of Ngati-Apa, for taking fern-root and eels on the Kuha-waea Block, at Galatea. Serious inter-tribal wars were often caused by these acts of trespass.

"*Te manawa nui o Whete*" (the sustaining-power of Whete) is a local saying applied to the fern-root. Whete was a valorous ancestor who, prior to going into battle, would consume a large quantity of fern-root cakes, and then perform prodigies of valour.

"*Kaua e patu i te aruhe i te po. He upoko tangata, he tohu aitua.*" Do not pound fern-root at night-time. A human head, an evil omen. If you do so, then your head will soon be pounded by the weapon of an enemy.

"*Ka ora karikari aruhe, ka mate takiri kaka.*" The fern-root digger will survive when the parrot-snarer is assailed by hunger. You can obtain fern-root at any season, but parrots are only taken during the winter.

Roi = *aruhe* = fern-root. A generic term.

Rotari. } A term applied to young fern-root not yet fit for
Kotau. } digging.

Aupatu aruhe. A bundle of dried fern-root.

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* This club, termed by Tuhoe a *patu aruhe*, but by some tribes a *paoi*, is here made of the hard wood of the *maire* tree, but among some tribes stone ones were used.

Mata kai awatea. A term applied to fern-root. The first word is probably *mātā* (see above), while the last two words refer to the prejudice against pounding fern-root at night.

Te aka o tuwhenua is another expression used for fern-root. The creeper of the solid earth, in allusion to the far-reaching roots of the *rarauhe.*

He Tau (a Song).

He aha te kai e ora ai te tangata
He pipi, he aruhe,
Ko te aka o tuwhenua
Ko te kai e ora ai te tangata
Matoetoe ana te arero i te mitikanga
Me he arero kuri
Au!

THE PEREI.

"The *perei* is an orchid, scientifically known as *Gastrodia cunninghamii.* It is not at all a common plant." *

When camped at Ruatoki last summer our camp cook drew my attention to several plants of *perei* growing near the creek, where they were sheltered by a growth of scrub, and so protected from stock. The stalks were from 2 ft. to 3 ft. in height. At the foot of each was a mass of small tubers or roots from ½ in. to ¾ in. in thickness.

Some singular notions prevail among the natives in regard to the *perei.* It did not, according to the Maori, originate in or from the earth, but was formed by the gods. Again, when engaged in digging for the roots the word *perei* must not be mentioned or no roots will be found. At such a time it is termed *maukuuku.* For a similar superstition in Tahiti, see Tregear's Dictionary under *Kapara;* also a singular note concerning the mandrake-root in Lang's "Custom and Myth." Similar beliefs also exist among the Maori in regard to birds.

The *perei* was dug in the winter season, and dried by exposure, as fern-root is. It was either roasted at a fire or cooked in the steam-oven. It was not found in any quantity, but would be dug up when seen.

TI (*Cordyline*, the Cabbage-tree of the European Settlers).

The *ti* is known on the East Coast as *kouka,* and in some other districts as *whanake.*

The various species of *Cordyline* as recognised by the Tuhoe Tribe are as follows:—

1. *Ti kouka (Cordyline australis),* the common "cabbage-tree."
2. *Ti kapu (Cordyline banksii).*
3. *Tōī (Cordyline indivisa).*

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* From Mr. T. F. Cheeseman.

4. *Ti ngahere.*
5. *Ti para.*

The *ti tawhiti* does not appear to have been known here, unless it is identical with the *ti para*, above.

All of the above species provided food for the Maori. The young leaves were sometimes eaten. The roots of the above varieties of *Cordyline*, except that of the *toi*, were all eaten. The top or head of the tree was cut off in the fourth month of the Maori year—*i.e.*, the month Mahuru, which is the spring month (August–September)—in order that the sap might not rise, or, as the Maori puts it, that the sap might return to the tap-root. Then, when the planting season (*koanga*) arrived the root of the tree was dug up, usually in the fifth month of the Maori year, and placed in a steam-oven, where it was cooked for two days. It was then taken out and allowed to become cold before being eaten, the fibrous matter being, of course, rejected. It is said to be remarkably sweet. Hence, doubtless, the reason why it was prized by the natives, whose saying for the food, "*He kouka ki te awatea, he ai ki te po*," shows the estimation in which it was held.

The *ti para* was the most highly prized of the *Cordyline*, as it furnished the best food material, and both trunk and tap-root (*more*) were cooked and eaten. The trunk was about 2 ft. to 3 ft. in height in this district. This variety was cultivated for food, and does not appear to have grown wild here. It is now extinct in the district. This variety is said to have been eaten by the chiefs only.

The head (*kouru*) of the *toi* was cooked in a steam-oven and eaten—*i.e.*, the top of the trunk, which is the soft part, the young unexpanded leaves of the tree. This section of the trunk was split into two or more pieces before being placed in the oven.

Tradition states that one Roau brought seeds or plants of the *ti*, *taro*, and *karaka* (a tree, *Corynocarpus lævigata*) to New Zealand in the "Nukutere" vessel. The two former are known in this district as *Te huri a Roau* (the seed of Roau). The *ti* brought by him is said to have been planted at Pokerekere, and its name was Whakaruru-ma-tangi. The "Nukutere" canoe made the land at Waiaua, near Opotiki.

RAUPO (*Typha angustifolia*, Bulrush).

The soft, mealy roots of this swamp plant were eaten, the larger ones being selected for food. These roots are termed *karito*. The outer part was peeled off, leaving the soft interior, the *iho*, which was eaten both raw and cooked in a steam-oven (*hapi*).

A peculiar kind of food was made from the pollen (*tahuna*

among the Mātātua Tribes, but termed *tahune* elsewhere) of this plant. The *tahuna* is described in Williams's Dictionary as the "pappus of seed of *raupo*." The *raupo* is only found on the outskirts of Tuhoeland, hence it did not form an important part of the Tuhoean food-supply. A good description of the making of a sort of bread from the *tahuna* may be found in the Rev. Taylor's "Te Ika a Maui." My own notes on the subject are meagre.

We will now see what berries or fruits were included in the food-supplies of the Tuhoe people, this being an important source of food of these forest-dwelling people, for the three principal items in such supplies were the berries of the *hinau* and *tawa* trees and birds.

The berries of the *hinau* (*Elæocarpus dentatus*) were largely used in former times, and even now to a small extent. The kernel of the berry is covered with a mealy substance, which is the edible part. This meal is made into a sort of cake and so cooked. The berries are collected from the ground under the trees into baskets and put into a house until dry, probably for a couple of days. They are then poured into a wooden trough (*kumete*), and pounded with a short club or pestle of hard *maire* wood or stone. This process is termed *tuki*, and is to free the meal from the stones of the berries. The pounded berries are then put in a basket, which serves as a sifter, and is made of strips of *ti* leaf, with small openings left between the strips. This basket is called a *tatari* or *kete puputu*. The meal is sifted over a closely woven mat, and the meal escapes from the basket and falls upon the mat, the stones of the fruit being retained by the basket. This meal is then put into another basket with smaller spaces and again sifted, in order that any stones (*karihi*, or *iwi*, or *iho*) that may have escaped the coarser sieve will be retained. The refuse—*i.e.*, the stones—still have a certain amount of meal (termed *renga*) adhering to them. They are therefore cast into a wooden trough or bowl, water is poured over them, and the mass is stirred about with the hands until the adhering meal is washed off. Then the stones are scooped up with the hands and cast away. The meal-and-water mixture (termed *wai haro*) is then stone-boiled (*huahua*) by means of throwing hot stones into it, and is then drunk. It is a sort of gruel.

The meal which has been sifted is collected from the mat and placed in a bowl, where water is poured on it, and it is mixed (*poipoi* and *pokepoke*) into a mass and then placed in shallow baskets termed *rourou*. These baskets are made from the leaves of the *mauri* or of the *kokaha* (probably both *Astelia*), and are lined with leaves of the *paraharaha*

(a fern). The meal in the basket is also covered with the same kind of leaves, the covering process being known as *raupi*. By this time the steam-ovens are ready, and the baskets of meal are put into the ovens and covered up. They are cooked for two hours or more, and are then taken out and placed in the food-stores, where these cakes, or rather steamed puddings, will keep good for a long time. In late times the meal has been mixed with honey in place of water. In appearance this food when cooked is dark in colour, and looks both solid and heavy. It somewhat resembles a dried linseed poultice. I have eaten it, but may say that I prefer my bread and beefsteak. This, however, may be mere racial prejudice on my part.

The following saying is applied to the above food: "*Kia whakaara koe i taku moe, ko te whatu turei a Rua*" (When you awaken me from my sleep let it be for the purpose of eating the *whatu turei a Rua*—*hinau* meal).

Tawa.

The kernel of the fruit of the *tawa* tree (*Nesodaphne tawa*) furnished a large proportion of the food of these bushmen in former times, and, moreover, it was an article that could be kept as a stand-by for years. Hence during seasons when this fruit was plentiful large quantities of the kernels were dried and put away in the food storehouses.

The kernel only of this fruit is preserved. The pulpy outside matter is only eaten by children. This food is still in use here. The fruit is collected from beneath the trees where it has fallen and spread out to dry, after which it is placed upon a flax mat and beaten, in order to free the kernels from the skins and pulp. In cooking the *tawa* berries natives are most careful in preparing the steam-oven for same. After the fire is raked out and the oven arranged a layer of *karamuramu* leaves is used to line the oven with, then a layer of fronds of the *heruheru* fern is put in, then a layer of *manono* (syn., *raurēkau*) leaves, then a layer of *hanehane* leaves, then one of leaves of the *rau-tawhiri*, and finally a layer of fronds of the *paraharaha* fern. The kernels of the *tawa* are then poured in loose and covered with the same covering (*rautao*, generic term) and the oven closed. The *paraharaha* leaves are said to have the effect of destroying the natural odour or flavour of the *tawa* kernels and of imparting to them its own. These particular leaves are used because they are said to impart a brown appearance to the *tawa*, which colouring is considered desirable. They are allowed to remain in the steam-oven for forty-eight hours before being taken out. This long process of cooking is termed *tāwhăkămoe*, or *taopaka*. After the long steaming they are spread out on mats until thoroughly dry,

when they are put away in the stores. When it was required that a meal of the *tawa* should be prepared, the kernels were placed in a wooden trough with water and stone-boiled until soft, when they were pounded or mashed and so eaten. The Arawa people use their boiling springs instead of the steam-oven for the above purpose. Latterly it has been the custom to mix honey with the mashed kernels, and, of course, stone-boiling is a thing of the past. The ovens used for such purposes as the above were long ones, and not the small round kind generally used.

Tutu.

A peculiar article of food was made from the berries of the *tutu* or *puhou* shrub (*Coriaria ruscifolia*), also known as *tūpākihi*. The berries of this shrub grow in clusters, and ripen in the seventh and eighth months of the Maori year (Hakihea and Kohitatea). The clusters are plucked from the branches and squeezed or crushed in a bowl (*kumete*), and the stalks thrown away. A small bag or basket is made of split strips of *ti* leaves, and some plumes of the *toetoe* (*Arundo conspicua*) placed inside it as a lining. This bag is termed a *pu tutu*. The liquid mass of crushed berries is poured into the *pu*, which is suspended over a bowl, which receives the liquid as it drips from the *pu*, but the *huarua*, or seeds, of the *tutu* berries are retained by the lining of the bag.* The juice is usually kept in gourds, where it soon becomes *tetepe*—*i.e.*, "set"—and resembles jelly, but is more liquid below than on top. Prepared fern-root was sometimes mixed with this jelly. Thus prepared the berries are quite harmless, but if eaten before being strained, and so freed from the poisonous *huarua*, then the result is disastrous. Many natives died from eating these berries in former times, principally children. Persons so affected were placed bodily into cold water, and, it is said, would sometimes recover when treated so. Since the advent of Europeans salt has been used as an antidote for *tutu* poison; presumably it was used as an emetic. Te Rauna, of the harassed Poho-kotia Tribe, when so poisoned, took about half a bottle of painkiller as a cure. He survived both poison and cure.

Fern-root was usually eaten with the *tutu* in this district. In an account of his sojourn in the Ngati-Porou country, on the East Coast, the Rev. Mr. Colenso says, "In the houses of the natives a quantity of thick succulent fucus was hung up to dry, which they used as an article of food, mixing it with the expressed juice of the *tupakihi* to give it consistency. This fucus they called *rimurapa*."

Groves of the *tutu* shrub were often preserved to the right-

* The bag is squeezed in order to force the juice out.

ful owners by means of the *rahui*, of which more anon. Such a grove, called Ure-takohekohe, grew at Ohae, on the Whaitiripapa Block, at Ruatoki. Any person coming to take fruit from that grove in defiance of the *rahui* would be slain.

"*Me te whata raparapa tuna e iri mai ana te tutu*" (the *tutu* berries hang as thick and black as eels on a drying-stage) is a saying applied to the *tutu* when covered with the ripe fruit.

Te pu tutu e pehi mai nei
Kaore ka kite koe
Te taru kino nei
A te pukupuku nei
A te ruriruri na
Tena na, tena na
E hoki to kete
Waiho ano tatari ana
Kia whakawaia te kaki rourou—e.

Many kinds of small berries or fruits were eaten by the natives; for instance, those of the *rimu*, *kahikatea*, *matai*, and *totara* trees. In gathering these berries the person would climb far up into the head of the tree, and, gathering the same, would put them into a basket, which, when full, he would lower to the ground by means of a long cord attached to it. These baskets would be taken to a stream and the contents washed to free the same of leaves and rubbish, after which it would be eaten, without cooking.

The berries of the *tapia*, a parasite which grows on the *puahou** tree (syn., *houhou* and *tauparapara*), are also eaten without cooking, as also are those of the *kotukutuku*† and *poporo*,‡ the fruit of the former being termed *hona* and that of the latter *kahoho*. The *karaka* does not grow in this district.

The small berries of the *mako* tree (*Aristotelia racemosa*) were eaten.

The flower-bracts (*tăwhără*) and fruit of the *kiekie* (*Freycinetia banksii*) were eaten, but this climbing plant does not obtain in these highlands, although it is found, together with the *nikau* and *mamaku*, in the lower part of the Whakatane Valley.

We now come to the plants, &c., of which the leaves were used as food, including several of which the undeveloped leaves were eaten.

Mamaku (*Cyathea medullaris*).

This is the black fern-tree of the settlers. The part eaten is that termed the *koata*—*i.e.*, the soft inner part of the upper

* *Panax arboreum.*
† *Fuchsia excorticata.*
‡ *Solanum aviculare.*

portion of the trunk. The main part of the trunk and the curled undeveloped fronds were not eaten. *Koata* is a term applied to the upper part of acrogenous plants, and from which the leaves or fronds grow. This section is cut off and then the hard outer part is chipped off, a stone axe being formerly used for these purposes. The soft interior part is then cooked in a steam-oven for forty-eight hours, but the food is always eaten cold.

The *koata* of the nikau was also eaten, the circular butts of the leaves being stripped off (*koere*) until the soft, white, edible inner part is reached. "*Mehemea ka koeretia te rau o te nikau, ka rără te waha*" (when a leaf of the *nikau* is torn off its voice shrieks), said my informant, alluding to the peculiar sound caused by tearing off these leaf-bases. We have already seen that the *koata* of the *Cordyline* are used in a similar manner.

I am informed that a species of *harakeke* (*Phormium tenax*) formerly grew, or was cultivated, here at Rua-tahuna of which the bases of the leaves were cooked and eaten. It must surely be very different to any *harakeke* I wot of. The leaves were dark-coloured (*pango*), with brownish (*whero*) edges.

We will now give a list of small plants of which the leaves were eaten as we use greens, and which therefore come under the generic term of *puwha* with these people, and of various other plants of which the berries, &c., were eaten.

Raupeti, a *Solanum* : Leaves eaten as greens.

Poniu : Leaves eaten.

Pohue : A climbing plant, a convolvulus. The leaves are eaten here, but among some tribes the roots are eaten. There appear to be two kinds here. One, bearing a white flower, is found growing among fern and scrub; the other, which has a pink flower, is seen in swamps.

Pikopiko : This name is applied to the young, curled, undeveloped fronds of *Asplenium bulbiferum*. A favourite *kinaki* for potatoes.

Rērĕtī : A fern; the young fronds eaten.

Pārăhărăhă : A fern; the young fronds eaten.

Pŏrŏrŭa : The leaves were used to wrap round *kiore* and *kokopu* when being cooked. The wrapper (*kopaki*) was then eaten with the food it enclosed.

All the above were cooked in steam-oven and eaten as greens.

Pukatea (Gnaphalium (?) luteo-album) : The young leaves were chewed by children.

Panakenake : A kind of chickweed. Cooked as greens.

Kohukohu : A kind of chickweed. Cooked as greens.

Tohetaka (the introduced dandelion) : Leaves eaten.

Maikaika: An orchid (*Microtis porrifolia*). A small plant. The roots produce a small tuber or bulb. Eaten by children. Sometimes tubers are roasted.

Pakauroharoha (Polypodium (?) semigerum): A fern. Young fronds eaten.

Pa totara (Leucopogon frazeri): Berries eaten by children.

Kukuraho: A swamp plant. Roots or base of plant eaten. Roots are covered with peculiar black knobs—*ko aua mea pango nei, ko nga raho ena o Tuna* (the eel-god).

Para taro.—This is unknown to me. It is no longer found here, though said to be still found growing in the wild country up the Waioeka River. It was formerly eaten. It is said to have leaves something like those of the *nikau*, but small.

Pororua, rau-roroa, and *puha-tiotio* are three kinds of sow-thistle, all eaten as greens.

Ongaonga: The tree-nettle (*Urtica ferox*). The name *puruhi* is also applied to it, and sometimes it is called *houhi*. It is the inner bark which is eaten, a thin film resembling the inner layers under the bark of the *houhi* (*Hoheria populnea*). It is not cooked in any way, and has a sweet taste. The *ongaonga* is said to begin life as a number of small plants, which spread (*papa uku*) over the ground, and are afterwards replaced by a single large stem.

The Rev. Mr. Colenso states, in his pamphlet before quoted, "The natives [of Rotorua district] masticate continually a kind of resinous gum, insoluble in water. This they obtained from the *pukapuka* (a shrub)." I cannot ascertain that this gum was so used here, but a gum which exudes from the *manuka* was eaten.

Harore.

Under this generic term the Maori places many kinds of small plants, all of which are termed "toadstools" by us bushmen. Many of them were used as food formerly, and are still used to a less extent. Those coming under the generic term of *harore* grow up in the winter-time or as winter comes on, and are then collected, cooked, and eaten. They comprise the following kinds:—

Hawai: This is often eaten without cooking. Grows on dead stumps and trees in summer-time.

Wairuru: Grows in winter, from ground; generally found among *petipeti* plants and at base of *tawa* trees.

Tiki-tehetehe: Grows among *manuka* and not in bush. Grows all the year.

Maiheru: Grows from ground in open country all the year round.

Tipitaha: The mushroom.

Ipurangi.

Waewae-atua.

All the above kinds are eaten. One kind of *harore*, known as the *puapua-a-autahi*, is poisonous. It is sometimes called *mekemeke*, on account of its rough surface (*humekemeke* = *whekewheke*, terms applied to a rough surface, as of bark, &c.). Should a person eat the *puapua-a-autahi* raw, or without being properly cooked, he will be seriously affected thereby, and stagger about, unable to control himself. To cook this article it was wrapped in many layers of leaves of the *rangiora* shrub, then tied round, and baked among hot ashes and embers. When cooking-pots were acquired then it was boiled. The *puapua* grows in spring, from the ground, and is usually found growing among *puahou*, *rautawhiri*, and *kokomuka* trees.

If *harore* grows plentifully it is said to be a sign of a lean season (*tau hiroki*); other foods, birds, &c., will be scarce. *Harore* is cooked by what is known as the *tupuku* method—*i.e.*, it is put into a basket and that basket is placed bodily in the steam-oven.

The species termed *keka* and *hakeka* (syn., *hakeke*) is not here styled a *harore*. It grows on dead trees and on decayed logs of *tawa* and *mahoe*. It grows all the year round. Some *puwha*, or greens, and in late times potatoes, are cooked with the *keka* as a *towhiro*. This latter term is applied to any food cooked and eaten with an inferior food in order to render it palatable, a practice which formerly obtained in seasons of scarcity. Hence the greens or potatoes are eaten with the *hakeka*, which is, I believe, the fungus of commerce (*Himeola polytricha*).

Another variety of such food is the *tawaka*, a species of *Agaricus*. This plant grows in the summer, and upon dead trees or logs of *tawa*, *houhi*, and *mahoe*, hence it is not termed a *harore*, which spring up in the winter. The *tawaka* grows to a great size; I have seen them a foot across growing upon dead *tawa* stumps. These were eaten, and were cooked either in the steam-oven or stone-boiled in a wooden vessel. In the latter case "*ka mumura katoa te wai i tunua ai taua tawaka*"—the water in which the *tawaka* was cooked becomes red (or perhaps brown).

A curious superstition is connected with this plant: "If a person has eaten of the *tawaka* he is not allowed to go into the *hue* (gourd-plant) cultivations, for if he did so all the fruit of the gourd-vines would decay prematurely. Or were that person to go a netting the *kokopu* (*Galaxias fasciatus*, a fresh-water fish) he would not catch any, not a single one."

THE HUE, OR GOURD.

Although not properly belonging to this paper, I propose to insert the few notes that I have collected locally anent

the gourd. This plant does not flourish in this cold high-lying country, although it may possibly have been grown formerly in the lower Whakatane Valley—that is to say, below Karioi *pa*. When, however, Tuhoe acquired the alluvial flats of Ruatoki and Te Waimana they were then enabled to cultivate the *hue*, *kumara*, and *taro*. A few *hue* used to be grown at Omakoi, but they did not do well.

The *hue* was the only cultivated food plant possessed by the autochthones of New Zealand, and that was a poor one. The origin of the *hue* is said to have been one Pū-tee-hue, one of the offspring of Tāne (see genealogy). A learned native friend and tutor of mine said, "The name of the ancient *hue* is Pū-tē-hue. It was not brought hither from Hawaiki;* it was grown by Toi and his people, and came from his own ancestor, Pū-tē-hue. At the proper season the seed was planted. It was planted when the nights Turu and Rakaunui of the moon arrived [these are the seventeenth and eighteenth nights of the moon]. The following is the *karakia* (charm) used:—

Pū-tē-hue
Kia tuputupu nunui koe
Ka porotaka i nga ringaringa
Kia ahuahu nunui koe.

Pūtēhue said, 'The seeds which are within me shall be [vessels] for containing water for my descendants. Some of those seeds are male seeds, and they will not produce offspring.'"

In Maoriland seeds were planted at the full of the moon, in order to render them prolific and insure a good crop. Seeds of the *hue* (and of the pumpkin in late times) are subjected to a process known as *whakarau* before being planted. They are first soaked in water and then placed in a small basket (*kono*) which contains a mixture of earth and decayed wood (*popopo rakau*). The seeds are imbedded in this mixture. The mould is then covered over with grass or leaves, and the basket is buried in the ground near a fire until the seeds sprout, when they are planted.

When the *putaihinu* leaves of the gourd-plant are put forth, then the care of the cultivator commences, and he proceeds to loosen the earth round the plants. The above term is applied to the second pair of leaves put forth by the seedling. When the head of the embryo runner falls, that is the *hika* stage of growth; after that it starts to run (*toro*), and ashes are placed round the roots and under the runners to "feed" the plant. Earth is heaped round the roots and pressed down during the *hika* stage of growth.

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* *i.e.*, not brought by the last migration of Maori.

The product of the gourd-plant is only eaten while young and soft, before the rind becomes hard. In this stage it is termed *kotawa*. When grown they are used to contain water; these were the water-pails of the Maori. They were sometimes cut in half in order to form bowls (*oko*), which were formerly much used. The very large ones were used to contain preserved foods, birds, rats, *tutu* berries, &c. These are called *tahā*.

The following names are those of different varieties of *hue* as recognised by the Maori:—

Kokako-ware.
Whare-hinu.
Ikaroa.

We will now speak of some of the "small deer" that the Children of the Mist were in the habit of eating formerly, such as grubs, beetles, earthworms, &c., for all was fish that came to the Tuhoean net.

A grub called *mokoroa*, which is found in the *houhi* and *kai-wētā* trees, was eaten.

The small green beetle which is found on the *manuka* bushes when in flower in summer-time was an article of food. It is called *kekerewai* or *tutaeruru*.* It is also known as the *Manu a Rehua*, presumably a sort of emblematical term. They were collected in quantities and pounded up, then mixed with the *tahuna* of the *raupo* plant, already mentioned, cooked in a steam-oven by the process termed *tapora*—*i.e.*, packed in a small basket—and eaten.

The *moka* is a caterpillar which settles itself on the leaves of several plants, including the potato, and draws the edges of the leaves in to form a shelter for itself, and then closes the apertures with some whitish substance. There it remains until its wings grow. It also was eaten formerly, before plenty, in the form of the potato, arrived in the land.

The *anuhe* is also eaten while it is in its *mokoroa*, or grub, stage of growth. In this state it bores holes in logs and ensconces itself therein, covering the mouth of the hole with a sort of lid. To take them this lid is lifted and water poured into the hole, when the grub climbs out and is deposited in the stomach of the *Potiki a Tamatea*.

The *tuatara* lizard was formerly eaten, but has now disappeared from this district. Wai-o-hau and Tawhiu-au were places famed for these creatures, as also was Putauaki, or Mount Edgecumbe. The natives say that should a woman eat of the *tuatara* she would be doomed, because all the *tuatara* would collect and attack her.

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* The latter while in its young state.

The wood-boring grub found in logs or dead trees of *matai*, *rimu*, and *kahikatea*, and known as *huhu*, is eaten, either raw or roasted, in its first two stages of growth. The following are its names in the four stages:—

1. *Tunga rakau* or *tunga haere:* The ordinary grub state, actively engaged in eating wood.

2. *Tataka:* The grub ceases to bore, remains in a cell, and casts its skin.

3. *Pepe:* The wings and legs develope. Colour still white.

4. *Tunga rere:* Emerges from cell and flies abroad, a brown cockchafer.

Toke or Noke (Earthworms).

Here follows a list of the native names of the earthworms found in this district. Some species grow to a great length:—

Kuharu: A large, long, white earthworm. It is eaten.

Noru: A short white kind, found in stony places. Also eaten.

Wharu: A large worm, larger than the *whiti*, found in loamy soil. This kind and others which contain earth are stripped with the fingers before being prepared for eating. This forces the earth out of them.

Tarao.

Pokotea: A short white worm.

Kurekure: A short red or brown worm about 6 in. in length. Found in stony places.

Whiti: Usually found where a land-slip has taken place. These two last are famed for their sweetness of flavour.

Tai, or *noke tai:* A small light-coloured worm.

To cook these worms some water is placed in a bowl and rendered warm (not hot) by means of hot stones. The worms are then cast into the water and allowed to remain there for some hours. Before long (before the sun sets) the worms will have become dissolved, or partially so, but were the water too hot they would not melt. Some cooked *puwha* (greens) is added to the mess and a prized dish is ready; the gods who live for ever would smile at the sight of it.

The two most prized kinds, mentioned above, were reserved as food for the chiefs. The sweet flavour (*tawara*) of those kinds is said to remain in the mouth for two days. I cannot speak from experience.

Worms were preserved in gourds for some time. The best kinds were favourite *o matenga* of former days: the last food taken by a dying person is so termed. The flesh of the *kiore* was another favourite *o matenga*.

In the way of fish the denizens of Tuhoeland are probably worse off than any other tribe. In the first place, having no seaboard, they could do no sea-fishing, although doubtless they would occasionally obtain sea-fish from the coast peoples formerly in the way of presents. Again, the streams of this district have ever been poorly supplied with fish, the *kokopu* being the most numerous. Eels have always been scarce here on the headwaters of the Whakatane, Tauranga, and Whirinaki Rivers. The natives also state that there are no eels in Waikare-moana. Other smaller fish were also scarce.

The origin of the eel, according to the mythology of the Maori, is, like that of other fish, the great Tangaroa, who presides as a sort of tutelary deity over the denizens of ocean, stream, and lake. One Tuna, or Puhi, is often mentioned in legend as the eel-god, a sort of supernatural creature, who is credited with the performance of some singular deeds.

This Puhi, *alias* Tuna, appears to have flourished far back in the night of time, when heroes and demigods obtained. Maui, of immortal fame, discovered that Hine-nui-te-Po, the goddess of Hades, was carrying on something more than a flirtation with Tuna, the eel-god. Maui, being attentive to the morals of other persons, proposed to put a stop to the above state of things. He did so by destroying Tuna. This was one of Maui's acts which eventually caused his death, for Hine was not taking interference quietly, and so, by dread arts of magic, caused the death of Maui.

In White's "Ancient History of the Maori," vol. ii., page 69, we read that Maui married Hine, a daughter of Tuna and Repo, and that he slew Tuna for interfering with Hine. When slain the head of Tuna fled to the fresh water, and that is the origin of fresh-water eels; while the tail of Tuna fled to the ocean and became the conger-eel.

At page 76 of the same volume a Ngati-Hau legend states that Hine was a sister of Irawaru, and Tuna a son of Manga-wai-roa. Also that Tuna concealed himself in a pool named Muriwai-o-Hata (? Muriwai o Ata), where he was slain by Maui. "Then from the body of Tuna sprang Puku-tuoro, which is the monster (*taniwha*) of Aotea-roa." And it is the blood of Tuna which renders red the *totara*, *rimu*, and some other timbers.

The *tuoro*, according to the Tuhoe legends, is a huge monster which lives underground and burrows great tunnels as it moves on its subterranean way, uprooting trees and changing the face of the earth, for the valley of the Waikare Stream at Maunga-pohatu was so formed. There is a place at Te Whaiti called Te Ana Tuoro (the Tuoro Cave), albeit the cave has long disappeared.

One authority here states that Maui married Pani, and it

was Pani who was interfered with by Tuna, who lived in the water. Ngati-Awa say that Pani, she who gave birth to the *kumara*, was the wife of Rongo-maui. Another legend gives Pani as being another name for Taranga, the mother of the Maui brethren.

This Puhi has been extremely useful to the Maori, however. Persons of sufficient priestly power could obtain his assistance when in trouble upon the waters, and Puhi would convey them to land.

The following is a list of names of varieties of eels as known to Tuhoe:—

Papa-whenua.
Whakaau.
Kokopu.
Paewai.
Rino.
Matamoe.
Mohu.
Horewai.
Rewharewha.
Kaiherehere.
Tata.
Ngaeroero: A name applied to small eels.

Three different methods of taking eels were usually followed—viz., spearing, taking in eel-pots, and bobbing. The eel-spear (*matarau*) is an implement about 3 ft. in length, and consists of a straight shaft (*tātā*) with several tines or points of hardwood ingeniously lashed on to the end. These points are usually of *mapara*, the remarkably hard resinous inner part of the *kahikatea* tree, which is left sound and hard after the rest of the tree has decayed. The two small cross-pieces of wood lashed across the tines (*mata*) of the spear are termed *kauaerua*. The lashing underneath is *tui ihu*.

The bob used is a small ball of dressed fibre of the native flax, the fibre of which is called *whitau*, but the green plant is *harakeke*. The bait (*mounu*), consisting of earthworms, is tied on to the bob, which again is attached to a fishing-rod by a short cord. The bob is used for taking eels and *kokopu*. The rod used is called *matire*, a name which, in Nukuoro, is applied to the bamboo. The use of the *rohe*, or fish-bag, while bobbing, is explained under "*Kokopu*."

Eel-fishing in the day-time was formerly done with the spear, but since the advent of Europeans a steel fish-hook, fastened firmly to the end of a stick, and with which the eels are hooked, not fished for, has come into use. Anyhow, the fisher trudges off, sans clothing, and prowls along in the

stream, feeling under the banks with his hand for the wily *tuna* (eel, generic term), and groping under stones in the river-bed with his feet. Should he feel the water somewhat warm to his foot he knows that there is an eel near the spot, and proceeds to spear or hook it.

In eel-catching by torchlight (*rama tuna*) the fishers start when the *koko* birds have ceased singing in the evening (*kia mutu te ko a te koko i te ahiahi*), not the short song given by that bird towards midnight. The spear was generally used formerly, though some fishers used hand-nets, like those used for taking *kokopu*, but larger. The eels are seen lying on the bottom in pools and calm reaches, and can be approached ie the fisher is careful not to disturb the water, or "shake it," as the natives put it.

If moths are seen to be numerous round fire, that is a sign of a good night for eel-fishing. In rainy weather also is a good time—that is, the *marangai*, which is an "eel rain"—and the Maori proceeds to set his eel-pots. When day dawns then *Tangaroa* will perish. A cloudy night (*po tuahuru*) is good for eel-fishers.

Tuna-kapakapa is a small tributary of the Whirinaki River, near Te Whaiti. In olden days the natives cut a ditch from some distance up this stream to the Whirinaki River, and used to turn the creek into it. When eels were travelling the water would be turned off into the old bed, which left the eels writhing in a dry channel, and thus easily secured. Hence the name of the stream—Tuna-kapakapa (writhing eels).

When a young man went eel-fishing for the first time he had to be most careful in regard to his catch. On returning to the village a fire was kindled and the eels cooked. This fire is termed an *ahi parapara*. On no account might women be allowed to partake of this catch; only males might do so. This is in order to insure good luck for the fisher in the future, that he may be a successful eel-fisher. Afterwards his catch may be distributed among the people. As the Maori of old put it, "When Tangaroa perishes in the *hinaki* (eel-pot) then the *ahi parapara* is kindled." This rite comes under the generic term of *whakaepa* (conciliation), concerning which there are many customs and invocations, all for the purpose of procuring good fortune for the invokers. Eels are sometimes cooked by the *tapora* process—*i.e.*, put in a small basket woven of *mauri* or *kohaha* leaves (*wha*), and then covered over with *puwha* or *mauku* leaves, and so cooked in the steam-oven, the said leaves being eaten as greens. If these greens be not obtainable, then leaves of the *pa-raharaha* and *rereti* ferns are used. Or they are sometimes cooked by the *kopaki* process—*i.e.*, wrapped up in the leaves

of the *rangiora* and so cooked, the leaves being plucked two on a stalk for the wrapping or binding (*kopekope*) process, which is cleverly done, no tying being necessary. In this style of cooking the eel is cleaned, and the entrails cooked in a small separate *kopaki*. In the *tapora* they are not cleaned. To cook in a *hangi* food wrapped up in leaves is denoted by the generic term *konao*.

Eels are preserved for future use by means of drying over a fire termed an *ahi rārā tuna*. They are split open, cleaned, skinned, the backbone taken out, and the head and end of tail cut off, and then laid on a staging of green sticks over a fire, which dries and half cooks them. They are then packed in baskets in layers (this packing process is termed *whakamūtā*), or sometimes simply hung up in a shed. These dried eels are cooked in a *hangi* when required.

Natives state that eels when in pain, as in being speared, make a peculiar sound (*ka kēkē te waha*).

One Hine-i-wharona is said by the Ngati-Manawa Tribe to be a sort of patron *taniwha* (demon, monster) of eels. This demon dwells in a lagoon at Te Puta-kotare, near Galatea, or used to do so. The eels which bear the *taniwha's* mark, a stripe or band, when caught, must be cooked in a separate oven and eaten by one person only, otherwise luck in eel-fishing will desert the tribe.

A huge eel which lived in a deep hole of the Whakatane River, at Ruatoki, used to come and help itself from the natives' nets when they were catching *upokororo*. Another famed great eel was Karitake, at Hana-mahihi; it was eventually caught with a large iron hook. Wondrous stories are told of some of these monster eels.

When in days of yore Tu-tamure and his daughter were crossing a range near Te Wera they fell athirst, whereupon Tu plucked a hair from his leg, and, casting it upon the ground, repeated so potent an invocation that a spring of water at once gushed forth from the spot. This legend is doubtless true, because my informant tells me that the spring still flows, and in it dwells an eel with eight tails. This spring is called Tangiwai and Roto-nui-a-wai. Another version says that it was Tamatea-nukuroa, a Nukutere migrant, who performed the above act, to assuage the thirst of his daughter Rangiwaka.

A curious custom obtained in regard to eels moving up stream. In order to prevent them from going up beyond the boundaries of the tribal lands a certain rite of the black art was performed, and a material token of the spell or ban was set up at the edge of or in the river, such as a pole. Such a one used to be at Puke-toatoa, on the lower Rangitaiki River. Another was a moving *totara* log, named Tangi-auraki, a

sawyer, at Nga-huinga, above Galatea. When the Native Contingent were stationed at Fort Galatea they are said to have tried to destroy the *mana* of this log, but without avail.

Pio, of Ngati-Awa, discourses on the benefits derived from the gods: "The ancestors who dwell in the heavens are the persons who assist and succour their descendants of this world. Those ancestors are Pueaea, Whaitiri-păpā, Ku, Whaitiri-pakapaka [the foregoing are personifications of thunder and thunderstorms], and Marangai-areare [personification of rain]. The benefits we derive from them are fine weather and rain. When they send down the rain of the heavens then the people within the waters move abroad and perish within the *hinaki* of the Maori. That tribe is [that of] Tangaroa. Their names are *paewai*, *rino*," &c.

It was customary in olden times to have a sort of talisman termed a *mauri*, which was really a material token or representation of certain rites and invocations performed and recited in order to preserve birds or fish. It prevented such being driven away from tribal lands and waters by the power of *makutu*, or witchcraft. It was often the case that a tribe would have several such talismans, one in the forest to retain the birds, another to protect eels in the rivers, and another by the coast for salt-water fish, not to speak of the *mauri* of the tribal home, which protected the people thereof from such harm as might be inflicted by means of the black art.

A *mauri* was sometimes located at an eel-weir. The *mauri* of the Rangitaiki River, in the Ngati-Manawa district, is a stone by the side of the river above Murupara. O-tangiroa is the name of an eel *mauri* in the Whakatane River, near Ruatoki. It is a log in the bed of the river, and eel-fishers used to repeat an invocation at that place when going a-fishing.

"*Kopaki tuhera, tu ana Tama-ika*" (When an oven of baked eels is opened Tama-ika is sure to be there). This saying is applied to those who make it their business to be where food is about ready for eating. Tama-ika was an ancestor who had a great liking for eels, and used to appear when any were cooked.

A fishing-ground is usually termed a *tauranga*, as *tauranga paewai*, a place frequented by the *paewai* eel, and hence where it is fished.

"*He ua ki te po, he paewai ki te ao*" (Rain at night, the *paewai* eel in the morning). Eels travel during a rainy night, and many will be found in the pots next morning.

Pārua: A hole about a foot deep dug in the earth by the side of an eel-fisher, and into which he puts his catch, unless he is using a *rohe*.

Kaui: A cord on which anything is strung or suspended, as *kaui tuna, kaui kokopu,* and *kaui tiki.*

EEL-WEIRS (*pa tuna* and *pa tauremu*).

On this subject I have practically no information to give, inasmuch as eels were, and are, very few in these parts, and hence weirs were not used inland, although they were so at and below Rua-toki.

Eel-weirs are made by erecting a sort of brush fence in the bed of the river, and constructed often in the form of a capital W with openings at the two lower acute angles—$^{1}\backslash^{3}\Lambda_{2}{}^{3}/^{1}$. Sometimes only one open space is thus left. To these outlets are fixed nets, known as *rohe* and *purangi,* in which eels and other fish are caught. The two lines of fence marked 1 above are termed *paikau* (wings). The middle part of the weir, marked 2, is called the *tuki.* The spaces marked 3 are occupied by the *whakareinga* (or *whakatakapau*), which are a sort of hurdle made by wattling fern or *manuka* brush, and which are staked down on the bed of the stream between the *tuki* and each *paihau,* extending as far as the open space. These are to prevent the water scouring out a hole in the bed of the stream. The fences are made by driving into the river-bed rows of stakes, termed *matia,* and wattling or tying fern or *manuka* brush to them in such a manner as to make a close fence; hence fish must pass through the spaces left open in going up or down stream.

The *hinaki,* or eel-basket, is still used by the natives in many parts, in rivers and also lakes and lagoons. The shape of this eel-pot is well known to most of us. The funnel-shaped entrance is termed the *akura,* and to the inner end of it is fastened a small piece of netting, called a *rohe,* which prevents any fish from passing out through the entrance. Eel-pots are made of small tough roots or twigs, such as slender *manuka* twigs, placed parallel and fastened together with fibrous rootlets, &c. The tough twigs of the *kāī,* or young *matai* tree, are also used, as are the tough creepers known as *tonakenake.*

The different outlets of an eel-weir often had special names assigned to them. The large posts of the weir were sometimes carved in the most elaborate manner, and the weir generally was quite a permanent affair, although the fences would occasionally need repairing or renewing. The *taumaha,* or first-fruits ceremony, performed over the first-caught eels of the season, was the same as that for birds, save that the name of Tangaroa was used instead of that of Tane, the former presiding over fish and the latter over forests and birds.

The following is a charm repeated to cause eels to come and be caught at an eel-weir:—

Te ika i Heretaunga, te ika i Ngaru-roro
Te ika i Tukituki, te ika i Porangahau
Te ika i Te Whakaki
Te takina mai ki te turuturu
Ki tenei tapa ngutu
Ki tenei tauremu
I whiwhia mai a Tangaroa
Tangaroa whiwhi
E tuku, e heke ki to moenga
Ki tenei kupenga, ki tenei tauremu
Ana oti kai a koe
Whiwhia, rawea.

Whereas the following charm is repeated by a person who is fishing for eels with a bob:—

To poa, to poa,
To poa tahuri ke
To poa ka rapa ke
Tikina mai
Kumekumea!
Tikina mai
Takatakahia!
Tikina mai
Haparangitia!
Tangaroa kia u
Tangaroa kia ngoto mai
Oi whiwhia, oi rawea
To poa,
Tahuri mai.

Here is another version:—

E Raro! E Raro!
Te Po
Te Po tahuri ke
Te Po tahuri mai
Tau mounu tikina mai
Kumekumea!
Tikina mai
Takatakahitia!
Tikina mai
Haparangitia!
Kia u
Kia ngoto.

The Raro here mentioned seems to be a sort of mystical term for the earth, or the underworld. A very ancient legend mentions that Puanga, Takurua, and Matariki (all star names) ascended from their mother Raro to the heavens; also that the *kumara* of Raro is the *kumara-hou* (a tree).

The expression "*kopua kanapanapa*"* is applied to the Kawerau Valley on account of eels and other foods being plentiful at that place. The following song refers to it:—

He aha taku tamaiti i waiho ai
I kakara ke (?) hei kai ra
Te whakahokia ai
Ki te kopua kanapanapa

* Also *kopua kaniwhaniwha*, applied to a deep dark hole in a river, &c.

E tuhera tonu nei.
He aha te kai o roto?
He rino, he kete taro mo potiki
He kàtokato no potiki
He kete uhi no potiki
Katahi nei au ka kai
I te kumara nei
Te katokato.

KOKOPU (*Galaxias fasciatus*).

This small fresh-water fish is well known to those who dwell in the lone places of the land. It is fair eating, but the bones are troublesome. It is best cooked in the native manner, in a steam-oven. The *kokopu* was, and still is, the most numerous fish of this district.

Natives recognise three varieties of *kokopu*, viz.:—

1. *Rau-mahehe* (known as *maehe* at Waikare-moana).

2. *Rĕrĕtawa*, smaller than *rau-mahehe*, found in shoals (*pahihi*); is the soundest sleeper.

3. *Pără*: The largest.

Koawheawhe: The young of the *para* are so termed.

Porohe, *koeaea* (or *kaeaea*), and *uruao* are terms applied to the young of the *inanga*, *kokopu*, and *tipokopoko* fish.

The first two of the list have not so many bones as the *para*, which requires much care on the eater's part. The reddish colour of some *kokopu* is said to have been caused by the blood of Murirangawhenua, when Maui washed the jaw-bone of that ancestor before using it as a fish-hook.

As observed, the *kokopu* is sometimes taken with a bob, but the usual method is by use of a hand-net, of which there are two kinds. The first kind of these nets (*kupenga*) is that used by women, who do most of the fishing for *kokopu*. To construct this net a piece of green supplejack (*pirita*) is procured, bent into an oval form, and the ends then fastened together. A piece of cord, called the *tautata*, has one end secured to one side of the oval hoop in the centre, and the other end is passed round the opposite side. Then by pulling the cord the two sides are brought to within 8 in. of each other, thus flattening the oval. The cord is so secured, and keeps the net-hoop from spreading. Another piece of *pirita* is bent in two places so as to form three sides, having two right-angles, the two upright ends being about 18 in. in height and the length of the bottom piece is 2 ft. The ends of this *titoko*, as it is called, are fastened to the above hoop, which is termed *tutu*, and the framework of the net is completed. The fastening of the *titoko* to the *tutu* is effected by doubling the ends of the former over the latter and so lashing them. A net is then made to fit this frame. It is made by knotting or netting (*ta kupenga*) narrow dried strips of undressed flax (*harakeke*), the mesh (*mata*) being ¾ in. in length. This net-

ting is done over a small flat stick, termed a *papa kupenga*. It is 6 in. to 8 in. in length and about ⅝ in. in width for the *kokopu* nets. It is used in order to insure regularity in the size of the mesh. This *papa* is slipped along as the work progresses. Nets with a belly (*ngake*) to them, as the large nets for sea-fish, are commenced in the middle. Two sticks are placed upright in the ground; to these a cross-piece on the top is attached, and to this piece the net being made is attached. The first row netted—*i.e.*, the *hiki*, or rib—is called the *ara whakamata*. The net for the above-described frame is made to fit the same, so that it fits tightly over it, and, when fastened to the *tutu*, that and the *titoko* keep the net taut and in position. The cord round the top of the net is bound to the *tutu* by a lashing (*aho whakamau*), except a short space left free on one side to enable the fisher to grasp the *tutu* in his hand when using the net. This style of hand-net is termed a *kupenga titoko*. A specimen may be seen in the Auckland Museum.

In netting a bellied net the desired shape is attained by the *mata whiti** (skipped mesh) process. This has the same effect on the shape of the net as the *tihoi* process has in weaving a cloak, as described in a former paper.

Another style of net used for taking the *kokopu* is that known as a *kape*, which is used by men. It differs from the *kupenga titoko* in form, and it is made of dressed flax-fibre. It does not narrow to the bottom like a woman's net, nor is the *tutu* rounded in any way, two of the angles being obtuse and two acute; hence one end of the frame, and necessarily also of the net, is wider than the other. This net is fastened to the end of a short pole, the free end of which is gripped by the fisher. The narrow end of the net is towards the user, and to this narrow end is attached the mouth of the *ngake*, a small net which serves the purpose of a fish-bag, for when a fish is scooped up in the main net the fisher raises the same and causes the fish to slip down into the *ngake*, where it remains until the fisher quits work or the *ngake* becomes full. Probably the above description is not very clear, but I hope to be able to secure one of these nets for the Museum ere long.

These nets are used at night, it being useless to try to catch the wily *kokopu* with them in daylight. The first thing done is to provide torches of the resinous *mapara* wood, strips of this being tied together for the purpose of making a torch, which is termed a *rama*,† hence the terms for taking *kokopu*

* Also termed *mata whakapaheke*.

† The verb is *tirama*, to look for with a torch, &c. This is a good example of *ti* as a causative prefix.

or eels at night—*rama kokopu* and *rama tuna*. The Tuhoean ladies march forth, bare-limbed and with fish-basket (*puwai* or *tauremu*) strapped round the waist, torch held in the left hand and net in the right. They wade up stream, keeping a keen look-out for the hapless *kokopu*. Now, this fish during the day-time is either concealed or moving about, but at night they come out into the middle of the stream, in the current (*ia*), and there lie and sleep, with their heads up stream and tails gently waving to prevent them from drifting with the current. The fisher, on sighting a fish, moves carefully until close by, and then quietly lowers her net (held in the right hand) and moves it up close to the fish. She then advances her left foot and gently touches the fish on the near side. The startled fish invariably darts off in the opposite direction, and hence enters the net, which is raised out of the water, the fish secured and thrust into the *puwai*, or fish-basket. Or, if a *kape* net is being used, the fish is allowed to slip into the *ngake*. The act of poking the fish with the foot is described by the verb *kape*, hence the name of the *kape* net.

The best time of the lunar month wherein to net *kokopu* is the Tangaroa stage of the moon—*i.e.*, on the *hinapouri*, or dark nights. The fish sleep more soundly then than at any other time. They do not sleep soundly on moonlight nights. There is one particular night of the first moon of the *nga-huru* (autumn) which is the best of all nights for taking *kokopu*, for they then sleep sounder than on any other night, and are even found sleeping in shoal places, half out of water, but jump away when touched.

Kokopu are taken in summer and autumn. They are said not to be good eating after the first frosts appear, for they then have a sickly apppearance and change colour, becoming lighter or grey-looking. It is said that they are affected by the frost. Also they do not sleep out in the stream during the winter, but conceal themselves.

In the autumn the *kokopu* go to the rapids to spawn, and at that time are not found in the calm reaches (*wahi tomarino*) of the stream. They lie concealed among the stones during the day-time, and at night come out into the current. Below are given the nights of the moon, as supplied by Tuhoe, together with remarks concerning *kokopu* fishing:—

Whiro (*kua kohiti te marama*): A good night for fishing.
Tirea (*kua aho*): A good night for fishing.
Hoata (*kua kitea*): A good night for fishing.
Oue: A good night for fishing.
Okoro: Fish do not sleep sound; a poor night for fishing.
Tamatea-tu-tahi: Not a very good fishing-night.
Tamatea-anana: Not a very good fishing-night.

Tamatea-aio: A bad night; fishers do not go out.

Tamatea-kai-ariki-whakapa: A bad night; fishers do not go out.

Ari-matanui: A bad night (*ka aho te rama, ka rere te ika, ka torohihi haere*—fish frightened by the torches).

Huna: A bad night; the fish are concealed (*huna*), hence the name of this night.

Mawharu: Not a good fishing-night.

Maure: Not a good fishing-night.

Ohua:
Atua:
Hotu:
Turu:
Rakau-nui: } Moon too bright for fishing.
Rakau-matohi:
Takirau:
Oika:
Korekore-whakatehe:

Korekore-piri-ki-te-tangaroa: Fishing begins after midnight (*kia kaukau ki te ao*).

Tangaroa-amua:
Tangaroa-a-roto:
Tangaroa-kiokio: } Good nights for fishing.
Otane:
Orongo-nui:
Mauri:

Mutuwhenua: A very good night.

The following is a charm or invocation repeated by fishers who are about to go a-fishing:—

> Taumaha kai te motumotu
> Kai te kapekape, kai te rorerore
> I aua kia mate, i aua kia irohia
> Ka ma Tūpā, ka ma Rakaihika
> Ka ma te kapititanga ki tamoe
> Tena hoki taumaha ka eke kai ou ringa
> Maire mai ki taumaha,
> Popoko mai ki taumaha.

The following is a charm repeated in order to beguile the *kokopu* into taking the bait (*mounu*) of the bob-line:—

> E kai, E te kokopu, i tana kai
> Ki te uru ti, ki te uru ta
> Ki taku wahine kotungatunga, koratarata.
> Hai konei, E Kopu E!
> Kopu nui, kopu roa
> E hi ana, e rawe ana
> Tongia!
> Tongia mai runga, tongia mai raro
> Tongia mai nga taita
> E hi ana, e rau ana
> Tongia!

The *rohe* is a kind of bag-net used by fishers of eels and *kokopu*. It is not termed a *kupenga*, presumably for the reason that it is not used for catching fish, but merely for holding them when caught. It is funnel-shaped, and the big end is fastened to a circular hoop of *pirita* (supplejack). It is made by netting (*ta*) strips of flax. The *rohe* is placed just before the fisher, and the lower end of it is in the water, while the upper part is above water. It is kept in position by means of two cords attached to the hoop and to sticks or branches by the stream-side. When a fish is secured it is swung up and dropped into the *rohe*, which really acts as a fish-basket. The term *hi* denotes fishing with a line (and hook or bob), but must be followed by *ika* (fish), or the name of the particular fish—as *hi tuna*, &c.—inasmuch as the original meaning of *hi* seems to have been "to draw up." Hooks were not used for taking fresh-water fish.

Kokopu are cooked in a *tapora*, a sort of small basket (though not called a *kete*) made of woven leaves of the *mauri* or *kokaha* plants. This is lined with fronds of the *rereti* fern and leaves of the *mauku* (*Asplenium bulbiferum*) which have been stripped from the stalk (*tuaka*) or midrib. The fish are placed in this without any cleaning, and covered over with *puwha*, or any leaves used as greens. The package is then tied and placed in the steam-oven for cooking. The *puwha*, *rereti*, and *mauku* are all eaten with the fish.

When a party start out on a night-fishing expedition they light their torches as they go forth. If a member of the party stops by the wayside that is a *puhore* (*ara ka noho ki te mimi*), or sign of non-success, and that person will not catch any fish. Should a person run his or her head into a spider's web on the track that also is an omen of non-success. Such persons will not attempt then to catch fish, but will carry the torches for the rest. If the first fish seen is not caught, but escapes, that is a *puhore* for the whole party, who will return without going any further. But if the first-seen fish is caught, then the person who caught it will at once throw it aside, not back into the stream, for that would be another *puhore*. His object in throwing it away is that he may be lucky in his fishing, and to insure the *puhore* afflicting only those who encountered the ill omens (*kia mau te puhore ki ona hoa i tu tohu anake*). There are innumerable customs and superstitions pertaining to fishing and fowling, but they must be reserved for a future paper.

In torchlight netting of *kokopu* the fishers usually proceed up stream in a straggling manner, but when returning they come down stream all abreast; because though most of those fish not secured by the fishers have concealed themselves, yet it is said that the *para* is attracted by the disturbance of the

water caused by the passage of the fishers and works up stream, following the muddied water, possibly finding food therein. Anyhow, they are so met by the returning fishers, who manage to secure some of them, although the fish are by no means asleep.

To preserve *kokopu* for keeping they are placed on a platform of sticks over a fire, but are not cleaned for this process as eels were. This fire is known as an *ahi rārā ika;* it dries and preserves the fish. When required as food they are cooked in a *hangi*.

At Lake Rotoiti a practice obtains of tying a cord to a bundle of fern (*rarauhe*) and lowering it to the bed of the lake. This bundle is termed a *tārŭkĕ*. It is said that *koura* (crayfish) and *kokopu* enter these bundles and lie there, attracted by the *nehu* (? pollen) of the fern. The bundles are hauled up and the fish secured. The *taruke* would appear also to have been used for taking salt-water crayfish, for which see a passage in White's "Ancient History of the Maori," vol. ii., page 63. But a net, known as a *paepae*, is generally used for taking *koura* in lakes. It is dragged along the bottom of the lake. The *ngehe* is a soft-shelled *koura*, found at Rotorua and other lakes. It is not eaten. It is soft and flabby (*konohenohe*). *Koura* are not found in the Ruatahuna district, but are found in lagoons at Te Houhi, in the Rangitaiki Valley. They are best eating in the summer season.

INANGA.

This small fresh-water fish is taken in great numbers in the lower parts of the rivers of this district, although not found in the headwaters of the Whakatane. They are taken in summer-time, in close-woven nets termed *pouraka*, and in former times used to be taken in great quantities at the eel-weirs at the time they were migrating to the sea.

"You have seen Rehua. It is a star which stands above, on the breast of his ancestor, Rangi. Rehua is a bird, and is an ancestor of the Maori people. He has one sound wing and one broken one, as you can see for yourself. Below the sound wing of that bird the Waka-o-Tama-rereti moves across the heavens. Whanui (Vega) swings up on the seaward side. The descendants of Rehua are the *inanga*, *pahore*, *koputea*, *kai-herehere*, and the *koko* bird.* On the nights Turu and Rakau-nui, of the ninth month [of the Maori year], they begin to migrate to their ancestress, Wainui. The reason is this: that they hasten to their female ancestor in order that they may give birth to their young. For his *inanga* descendants asked

* The first three are small fish, the *kai-herehere* is a kind of eel. The *koko* is the *tui* (bird).

Rehua, 'What are we to do?' And Rehua replied, 'When you see a gleaming redness in the sky, that is a call to you to go to your ancestor, Wainui, and produce your young. When they have grown they will return themselves.' There are three migrations of the *inanga*, and then the young are born and left with their ancestor, Wainui. These young are called *kaeaea*. This is the song for those young:—

Te kaeaea i tuku mai rara
I hara mai koe
I te tai honuhonu o Meremere
Ki maturu tara (?) koia.

So the young are left behind and the old return [to fresh water]. People see them returning, and observe that they are thin and light; and the Maori people note the red sign in the heavens, and the cry is heard, 'O, friends! the *inanga* are migrating.' Then the nets and pots are set at the weirs and great numbers are taken. Another great migration takes place during the *Kōhī o Autahi-ma-Rehua* (autumn), and again many are taken. The third migration is when Takero [a star] is seen, and the migration is known by that name. The *pahore*, *tuna*, *koputea*, and *porohe* join in it. In the months Matahi and Maruaroa the old fish return, but not yet the young. Many are caught as they return."

So much for Maori myth and observation. The natives assert that when the *Kōhī o Autahi* comes then all fresh-water fish migrate to the sea. Autahi is a star, otherwise known as Atutahi-ma-Rehua. The expression *Kōhī o Autahi* means the cold of autumn settling down on land and water. Wainui, mentioned above, is the origin and personification of waters of the ocean, rivers, and lakes.

The *inanga* produce their young in salt-water, and leave them there to be dashed about by the waves. Then the *hiwi* (their parent fish) return to fresh water, but the young ones do not come up the rivers until the fourth month (of the Maori year).

There is some confusion in regard to the various names allotted to these fish. Some assert that the *inanga* and *pahore* are different fish, but they are probably the same at different stages of growth. So far as I can make out, the terms *kaeaea* (or *koeaea*), and *tuarenga*, and *porohe* are applied to the young fish.* They are termed *inanga* about December and *marearea* about February. The old thin fish are styled *karaha* and *pahore* (*nga pahore o Rehua*). These latter are the old fish which have spawned, and it is said that the skin comes off them, hence the term *pahore*. The

* An old native tells me that the terms *porohe*, *koeaea*, and *uruao* are applied to the young of *kokopu*, *inanga*, and *tipokopoko*.

term *inanga* probably is applied here to the half-grown fish. *Marearea* is here the common name for the fish. The name *koputea* is applied to some of these fish which have white bellies.

Inanga are cooked fresh in the steam-oven, and were formerly dried in large quantities for future use. They would be packed in covered bundles or baskets or placed in bowls for preservation. They were dried by means of spreading on a shingly river-bed, and when dried (*pakā*) by the sun were packed in baskets. The term *whakahunga* is almost equivalent to *whakamātā*, before mentioned. It is applied to the above packing process, and also to the baskets of packed fish (*e rua nga kete whakahunga i a maua*).

The *korokoro*, or lamprey, is only found in the Waikare-taheke River in this district. It is taken in a large kind of *kape* net. When Matariki (the Pleiades) is seen by the eye of man, then the *korokoro* comes forth and strolls round the waters, and man is on hand to catch them.

The small fresh-water *patiki* is found in the lower part of the rivers, but not on the headwaters.

The *papanoko*, a small fresh-water fish, is eaten. Both it and the *kokopu* have decreased in numbers of late years. The *papanoko* appears to be termed *papane* in the north. It was often caught by hand.

The *titarakura*, also known as *tipokopoko*, *maruru*, and *toitoi* (the latter is the Arawa name), another little fish of these rivers, was formerly eaten until some few generations ago, when it became *tapu*, owing to the spirit of a still-born child entering it. It was taken by net.

There is a small fresh-water shrimp in the lower Whakatane River; and the *puene*, a little creature having six legs, is eaten by children.

The *upokororo*,* formerly plentiful in the lower parts of these rivers, but not found on the headwaters, has entirely disappeared since the war. The roe of this fish is known as the *roro o Tangaroa* (the brains of Tangaroa, the god of fish). It was taken with a net or at the weirs, which were built in numbers in the rivers near the coast in former days. Another way of taking them was by means of a *koumu*. A place is selected where a bend is in the river and low flat land or a shingle-bed in the bight. A ditch is cut from the lower river-side into the tongue of land, so that the water will enter it, but is not cut right through the tongue of land. The fish are then driven up stream, while persons stand in the river to prevent them going up past the mouth of the *koumu*, and

* "The *upokororo* go to the sea to spawn, but we do not know whether the eel and *kokopu* do so or not."

force them to enter the latter, when the entrance is blocked up and the fish taken. Sometimes, instead of the ditch, a wall of stones is built in shoal water.

Fish-hooks do not enter into this article, inasmuch as they were not used here. They were made of tough woods, as *manuka* and *tanekaha*, and also of bone. They were used for sea-fishing. *Puwai*, *tauremu*, and *papawai* are names applied to the fish-basket used here. It was tied at the side of the fisher by means of a cord round the waist.

The fresh-water mussel, or *kakahi* (*Unio menziesii*, Gray), was formerly an article of food here, but is not sought for now. A smaller variety, and lighter coloured, the *tairaki*, is found in Waikare-moana, and the natives inform me that extremely large *kakahi* are found in the old lake-bed at Te Pa-puni. The natives grope in the mud of lagoons with their feet and pick up the mussels with their toes. But in suitable places, such as Roto-iti, an instrument termed a *heki* is used. It is a kind of rake and net combined, with stones fastened to it to make it sink into the mud. The following is a song connected with the mussel:—

Tane rou kakahi—e
Aitia te ure
Tane moe i te whare
Kurua te takataka
Ara ra e! ki Rotorua ra
Kia kinaki ai ki te kumara
Ara ra! ka reka ra
Ki te umu tahanga nui.

The above *haka* was sung as a *heriheri kai** during the meeting of the *Kotahitanga* at Rotorua. A somewhat different version of the above appears in Grey's "Maori Proverbs," page 82.

Fishing-nets.

Besides the various kinds of nets already mentioned, the following were used in lake and river fishing:—

Kaharoa: A very large net, also known as *riritai*. As much as 14 *maaro* in length (*kumi ma wha te roa*). The *maaro* is the fathom of the Maori. This net required four men (*kai whakakau*) to manipulate it. Much used in tidal rivers. The word *whākau* describes the stretching of a net across a river—*ka whākautia te kaharoa.*

Korohe: A large net used for many kinds of fish.

Purangi: A net about 4 fathoms in length. It was set across a river and allowed to remain some time in position before being drawn. The expression "*Te kawau moe roa*" is applied to eel-pots, and such nets as are left in the water,

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* A song while food is being carried to visitors.

like the *purangi*, and not merely dragged. It is also applied to set bird-snares, because net, pot, and snare "sleep" day and night, but they secure food just the same. Hence the saying, "*Ou mahi, E te kawau moe roa!*" The *pouraka* net was used for taking the *marearea* fish. In these degenerate times a piece of scrim is used for a net for taking that fish.

Truly some strange things were eaten by the Maori of old; and one notes how they were keen for anything sweet to eat. Hence they ate the sweet gum which exudes from the trunk and branches of the manuka, and shook out the honey from the flowers of the native flax into vessels, which was sometimes kept for future use.

Another article eaten for its sweet taste was the *mimi koekoea*, as the natives here term it, but which is probably the excrement of that bird (the large cuckoo). It is found on the leaves of trees, often dropped by the bird when startled, and is licked off by the natives.

The *pororua*, *rau-roroa*, and *puha-tiotio*, three plants of which the leaves are eaten as greens, also furnished in former times a chewing-gum, of which the women and young people were extremely fond. This gum was the sap of those plants hardened and toughened by exposure. To procure it the leaves were plucked from the plants, and the white, milky sap, exuding from the wounded surfaces, gathered and stiffened on the stalks, when it would be collected and placed in a leaf. When a sufficiency was thus obtained it was pressed into a ball for use. The bitter taste soon disappeared on the *pia* being chewed, but it always retained a taste of its own. This chewing-gum was much used formerly. Such a ball would be handed down from mother to daughter. My informant possessed one which had been used by her family for three generations, until it was lost in the fight at O-rangikawa.

In times of scarcity a certain kind of clay (*uku*) was eaten. When the Kura-renga *pa* (fort), near Te Mahia, was being besieged by the Taupo, Tuhoe, and northern tribes, the garrison was reduced to the necessity of eating clay. The natives of Roto-mahana also ate a kind of clay found at that place.

Birds constituted the most important food-supply of these mountain dwellers. Apart from eating them while in season, they were preserved in great numbers for future use. *Kiwi*, *weka*, *kaka*, *koko* (tui), *kākāpo*, *kereru*, and also smaller birds, were preserved in the following manner:—

The birds are first plucked and cleaned, and then the bones are all taken out in the most ingenious manner, the process being known as *makiri*, after which they are placed in rough baskets termed *poutaka*. These baskets, with their contents, are then placed in cold water until the birds are

thoroughly cold and set. This tends to prevent them going bad (*koi kino i te pumahana, koi pirau*). On being taken from the water the birds are ready for the *ahi matiti*. This is the name of the fire at which the birds are both dried and cooked. Before a strong, clear fire are set up several stakes in a line. These stakes have a series of notches cut in them on the side next to the fire, the notches being cut in level lines on the posts, so that a straight pole may be laid in them. Another series of such notches is cut a little higher up the stakes, and so on. The birds are spitted on long sticks (*huki*) or poles, and when the pole is full of birds it is laid in the bottom row of notches (*kaniwha*) in the stakes (*pou*). Another series of birds are spitted on another pole, and the pole inserted in the next series of notches, a little higher up the stake. The series of notches are close enough to each other to allow the layers of spitted birds to overlap to a certain extent. This process is repeated until the *matiti* is full. Beneath the bottom row of birds runs a wooden trough—a wooden slab hollowed out (*kowaka*) —one end of which is raised somewhat higher than the other. Beneath the lower end of this trough a wooden bowl, or *kumete*, is sunk into the ground. The heat of the fire melts the fat of the birds, which fat drips into the trough (*waka*) and runs down into the *kumete*. When done the birds are placed in vessels, usually large gourds (*tăhā*), the calabash, or sometimes vessels of bark. Red-hot stones are now put into the bowl of fat until it boils (this process is termed *huahua*), and then the fat is poured into the calabashes which contain the birds until the birds are covered. These vessels of preserved birds (*tăhā huahua*) are then set away in the storehouses for use in the future. Rats (*kiore*) were preserved in a similar manner. Food so preserved is spoken of as *huahua*. The expression *matiti* seems to imply numbers —"*Matiti ana te haere a te koko ki runga ki te kahika*"— of a large number of *koko* (*tui*) birds alighting on a white-pine tree. The modern expression would be, "*Kore e rikarika te mahi a te koko.*" Te Matiti is a place-name at Te Whaiti.

When these calabashes of preserved birds or *kiore* were brought to adorn a feast, or be placed before a distinguished guest, they were adorned in a manner truly Maori. They were the centre-pieces of the banquet. The calabash was covered with a piece of fine woven matting and three or four carved wooden legs were lashed on, from the top of which were suspended bunches of feathers, from which the quills (*tuaka*) had been stripped, in order to render them less rigid. A carved wooden mouthpiece (*tuki*) was placed on the top of the calabash, and this was sometimes covered with a carved

wooden lid (*kopani*), and sometimes merely with leaves of the *rangiora* shrub. The hand is thrust through the narrow opening on the top of the calabash in order to procure the food within. The term *ngutu iti* is often applied to these vessels on account of the small opening.

Water was, of course, the universal drink of the Maori, and he has quite a fine taste therein. In olden times, when a bowl of drinking-water was fetched from the creek, and before handing it to the drinker, a few green fern-fronds were plucked and laid on the surface of the water, thus, to the Maori mind, rendering the water much more attractive. As my informant put it, "Even were the person not thirsty, yet he would drink of the water so prepared, the appearance of the leaves being so attractive"—*He momona nona ki te wai pena, ko aua otaota i tukuna ki roto i te wai hai whakainu atu.*

Before proceeding to speak of divers customs, &c., pertaining to food and the cooking thereof we have a few modern items to place on record, albeit they do not rightly belong to this paper, which is supposed to treat of the food-supplies of a non-agricultural people in pre-*pakeha* days. However, the word is "*Kohia nga maramara o Matatua*"—while yet the daylight is with us; and the shades of night are swiftly approaching.

When the potato and maize were introduced into New Zealand by the early navigators those food products made a great change in Maori life and domestic economy. More especially was this effect caused by the potato, which can be easily grown in all districts, and produces much food with a minimum of labour; and more especially did those tribes benefit from its introduction who are located in high-lying districts. Hence it became possible for the denizens of Tuhoeland to cultivate food, and swiftly they took advantage of it. For the first time the realm of Tane was invaded by the stone axe and fire, for by these agencies were the clearings made at Ruatahuna. Potatoes were acquired before intertribal warfare ceased, and it is astonishing to see the remote places in the wild back country where are the signs of former cultivations. Potatoes are now the main food of these people, and for some months of each year they have little else to eat, being too indolent to cultivate any variety of foods. In fact, when they speak of *kai* (food) they mean potatoes; to any other article of food the distinctive name is applied. In like manner the term *puihi* (bush) stands for wild pigs only. When a native says that he is going to hunt *puihi* he means that he is going pig-hunting.

The Tuhoe people first acquired potatoes in the time of Tangata-iti, of whom we give a genealogy:—

Ta-whakamoe
|
Kahu-wi = Moenga

- Tama-riwai
  - Karetehe II.
    - Te Motukura
      - Monika
        - Puihi (living 1902, an old man)
          - Te Amo-haere
            - Maata (a child of four years, 1898).
  - Te Rehe
    - Hine-hau
      - Te Uru-whiua (died 1900)
        - Taua (living)
          - Wairini (living, twenty years, 1902).
- Tangata-iti
  - Te Ahitahu
    - Numia (living)
      - Hine (About twenty years, 1900).

This genealogy will serve as an illustration of several remarks concerning the potato. It is probable that Tuhoe acquired their first potatoes from Ngati-Awa, the latter being a coast tribe, from whom these bushmen obtained their first European implements, &c., by means of barter. Moni, of Ngati-Awa, went north to the Ngapuhi country and brought back the first potatoes, guns, and steel axes to the Whakatane district. Now, many old natives assert that they possessed several kinds of potatoes, and cultivated them, long prior to the advent of Europeans. It is probable that they did so before they encountered any Europeans, having acquired the article from the far north, or other distant places, by means of the seed being passed from tribe to tribe. The evidence against the statement is this: that the generic terms for the potato (*riwai* and *taewa*) do not appear in song or story of ancient times as foods of the people, yet how often the *kumara*, *taro*, &c., are thus mentioned. Tamarau, of Ruatoki, mentions as evidence in favour of the pre-European theory that Moenga, mother of Tama-riwai (see genealogy), was living when the *riwai* was being cultivated; that, despairing of having a child, she dressed up a potato (*riwai*) as a sort of sooterkin, and nursed it as she would a child. Afterwards she gave birth to a son, and named him Tama-riwai, in memory of the potato incident. Quite so; but it is only three generations from Moenga to Numia, a middle-aged man now living, although the line is longer through Tama-riwai and Karetehe. The statement made by Puihi that the potato was acquired in the time of Tangata-iti may be but little removed from the truth.

Tamarau states that there were two kinds of potatoes in pre-European days—the *taewa* and the *riwai Maori;* that the latter had a smooth surface, without indentations. Its name was *waiararo*, the flesh being white and the skin *whero* (brown or reddish). The *taewa* had white flesh and skin. The peculiarity of the *riwai* was that it very soon became cold (*maeke*) after being taken from the oven. It died out during the late war.

Puihi says that the *rokoroko* and *araro* were two ancient varieties of potato cultivated at Ruatoki, but that they are no longer seen.

Pio, an old man of Ngati-Awa, told me that he had heard white men say that the natives had a potato in very early days; also that the *aka raupo*, a white potato, and the *tatairongo*, a dark mealy one, were formerly cultivated, but are now lost. Altogether, the case for the pre-European potato is not proven.

The following are names of varieties of potatoes as recognised by these natives:—

Piakaroa: A dark-coloured potato—*i.e.*, inside.
Tatairongo: Now lost.
Maori: Now lost.
Tápapa: White flesh. Also known as *karu-parera.*
Parareka: Dark flesh. No longer seen here.
Pokerekahu: Dark flesh. No longer seen here.
Pungapunga: One of first kinds acquired from Europeans. White flesh. Not seen here now.
Uwhi: Not seen here now.
Kapa or *parihi:* White flesh and white skin.
Tekepo: White flesh and white skin.
Kaparapara.
Aka raupo: No longer grown. White flesh and white skin.
Raparuru or *wairuru:* White flesh.
Maitaha: White flesh. Also called *rokeroke.*
Para-kokako: A dark-fleshed potato. No longer grown here.
Para-kotukutuku: A white flesh.
Kimokimo: A white flesh. No longer grown here.
Wini-harete: A long curved variety.
Manerau: White-fleshed.
Hua-karoro: A long white variety. No longer grown here.
Marikena (? American): No longer grown here.
Kamutana.
Kara kaone (? gown pattern).
Raramu.
Kotipo: No longer grown here.

Wharekauri.
Hope taone (Hobart Town).
Parakaraka : No longer grown here.
Kotuku-tahiti.
Hua mango.

The fruit of the potato (potato apples) are termed *takuru.* Potatoes growing from these seeds are termed *monemone,* on account of their smoothness, the indentations being small. The *takuru* of the Maori variety only were considered fit to eat.

The potato-crop is taken up in the month Pou-tu-te-rangi (about March). If left too late they deteriorate, in which state they are termed *tauhere* or *kopura.** New potatoes are termed *tamahou,* and old ones of last season are styled *pukeko.* Self-sown potatoes are termed *patohe,* but are sometimes styled *piwai,* from a word which describes rooting up an old cultivation with a *wauwau* in search of self-grown potatoes. The *wauwau* is a wooden implement used for rooting up fern-root, &c., and for loosening earth in fort-building. Some varieties of potatoes reproduce themselves for many years. When camped at Nga-putahi some time back I used to obtain my supplies of potatoes by turning up the soil in an old potato-ground all grown up in bush and scrub. It had been a cultivation of one Koura, and has been abandoned for many years. Observe :—

Koura
|
Mohi
|
Te Mauniko (living, an elderly woman)
|
Ripeka
|
Nuku.

This was the famous Koura, whose hand lay heavy upon the Pu Taewa and the Tiaki Tutu, or descendants of Tionga.

These people had a novel method of cleaning potatoes before the *pipi* shell came into use for that purpose. This was the *korua hukari kai.* A hole was dug in the ground and lined with bark. The potatoes were poured into this hole, and upon them was thrown a kind of sand termed *tenga kakariki* (from its resemblance to the inside of the crop of a parroquet). Then the ladies passed into the hole and trampled the potatoes with their bare feet; the friction caused by the trampling, helped by the action of the sand, rubbed the skin off the potatoes, which were then washed and cooked.

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* *Kumara* left in ground too long before being dug are termed *hou-hunga.* They will not keep, but are eaten at once.

The use of tobacco was soon acquired by the natives, and they used to obtain it from traders on the coast in barter. In fact, in the early colonial days these natives used to drive pigs from Ruatahuna all the way to Auckland in order to obtain European goods. Their names for the brands of tobacco so obtained are *purupuru*, *pongi*, and *parehe*, not to mention *nikahere* (negrohead). However, they obtained seed and have since grown their own tobacco, their names for the kinds grown here being *arero-kuri*, *porakaraka*, *taretare*, and *mohoao*, also a variety named *Witimoa*, after Major-General Sir George Whitmore, from whom they obtained the seed.

What is known as "Maori cabbage" is here termed *paea*. The natives say that it is named after a very early European voyager, from whom the seed was obtained. Now, Captain Cook was known as Paea amongst the natives of Poverty Bay, he being so named from the circumstance of calling out "Fire!" when he ordered his men to fire on the natives.

The *rearea*, a kind of *pohata*, or turnip, presumably introduced by early voyagers, was grown in cultivations and the leaves used as greens. It has very dark leaves. The root was dried and converted into *kao* in the following manner: The plant was grown in the enclosures used for growing potatoes, and when intended for *kao* the leaves were not allowed to be plucked for greens. When the root was matured the whole plant was pulled up and stacked away to dry in a *pataka* (food-store) or on a stage built in a hollow tree. When dry the roots were cut in pieces and cooked in a *hangi*, the *rautao*, or covering in the oven, being leaves of the *hanehane*, *manono*, *rau-tawhiri*, and *tutumako*, also fronds of the *paraharaha* fern. The roots became impregnated with the flavour of these leaves, which appears to have been considered desirable. The cooking lasted twenty-four hours, and the chopped roots were then taken out, placed in the food-stores to become dry and hard, after which they were placed in baskets, which were hung up in the cooking-sheds for a few days and then put away in the food-stores until wanted. When eaten this *kao* was placed in a bowl, water poured over them, and then pounded until mashed up; this porridge-like mixture was then ready to be scooped up with a wooden spoon (*koko*) and eaten. The term *kora* is here used as a sort of generic name for such things as are used as greens. The leaves of the *raorao*, *poniu*, and *raupeti* plants were used as greens, as also were those of the *rērēwai*, a water-plant.

When the natives first obtained soap here they took it to be pork fat, and essayed to eat it. Flour was thought to be ashes, and was sometimes thrown away as such. Molasses was thought to be the sap of the *rimu* tree.

Cooking of Food.

Possibly you might like to know the origin of the cooking of food. It is this: When Rongo-maui returned from the heavens (from the star Whanui) he brought back with him the *kumara* (sweet potato) and gave it to Pani-tinaku, saying "This food must be carefully prepared in ovens known as *kohukohu*, *kirihau*, *potaka*, and *waharoa*." "Hence the art of cooking became known to our ancestors. Had it not been for Rongo-maui men would have lived like birds, insects, animals, and other tribes of people, who eat their food raw."

One Auahi-tu-roa was the personified origin of fire by which food is cooked. Auahi-tu-roa was a descendant of the sun, and married Mahuika: thus the fire-children were produced.

Cooking is done sometimes in the open, but usually in sheds constructed for that purpose. In the earth floor of these sheds the steam-ovens are often constructed. These cooking-sheds are termed *kauta*, or *whare-kaunga*, or *here-imu*, or *muri* (also *kāmuri* in Williams's Dictionary).

The principal method of cooking formerly used was that of the steam-oven, termed *hapi*, or *umu*, or *imu*, or *hangi*, or *tonihinihi*, &c. This process of cooking is termed *tao*. Roasting was also practised, and is called *tunu*. Stone-boiling (*huahua*) obtained to a certain extent, as we have seen, but, it would appear, merely to heat food, &c., not to actually cook anything that required long immersion in boiling water. This latter was reserved for those people living near boiling springs.

Stone-boiling (*huahua*) was done in gourd bowls (*ipu*) and wooden bowls (*kumetē*). The term *kohua*, applied to metal cooking-vessels obtained from Europeans, is said by these natives to have been applied in pre-European times to vessels, such as the above, that were used for stone-boiling, as the latter part of the word would imply.*

We have already seen how the various foods of old were cooked by these bushmen of Tuhoeland. In these degenerate times cooking is mostly done in iron pots and "billies," and the potatoes and other foods so cooked are much inferior to those cooked in the steam-oven. In boiling maize some ashes of burned *rimu* or *kahikatea* bark are cast into the pot. This has the effect of causing the skin of the maize to peel off. The ashes of these barks are used because they do not grit between the teeth when the maize is being eaten.

The steam-oven is prepared in the following manner: A circular hole of the required size is made in the ground about 15 in. in depth for a small *hangi*, and in this a fire is kindled

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* Note the word *upoko-kohua*, certainly an ancient term. *Kohua* as derived from "go ashore" is not permissible.

and dry wood piled on. Stones are placed on the top of the wood, so that when the fire has burned down to a mass of embers these stones are extremely hot. The stones are then thrust aside with a stick, and the embers are raked out of the hole. The hot stones are then arranged in the bottom of the oven, and some water is sprinkled upon them until all ashes have been washed off the stones; or, if water be not used, some fern-leaves are placed on the stones. Then the *koronae* (or *koropae*), a woven band of *mauri*, or *kokaha*, or flax leaves, is placed so as to line the sides of the oven, thus leaving a circular space into which dirt cannot drop from the sides. The food is now placed on the stones within the *koronae*—potatoes, greens, and fish, or meat, or birds, or whatever the *kinaki* (relish) may be—and then water is plentifully sprinkled over the food, finding its way to the hot stones beneath. Then the food is covered with the *rautao*, a piece of matting woven of flax-leaves. Over that is placed the *tăkă*, another piece of matting, leaves of the *ti kapu* being the best material for this. This last mat is also known as *ritaka*. The whole is then covered with earth until no steam is seen escaping. When, finally, the steam is seen to burst forth, that is a sign that the food is cooked, and the oven is uncovered (*hukea*) and the food taken out and put in baskets.

The stones used for the ovens were carefully selected, a hard stone not liable to be fractured by heat being sought for. The stone termed *turua* is much esteemed for this purpose. Suitable stones were often brought great distances. In cooking while hunting or travelling any stones are used, and leaves used for covering food in an oven. When opening an oven, the earth is taken off, and then the covering-mats carefully lifted, shaken, and put aside for future use.

The *umu tahanga nui* is a term applied to permanent ovens constantly in use, as those of a permanent home.

The *umu konao* is an oven in which no fire is kindled. The stones are heated at a separate fire and then conveyed to the oven. This style of cooking is said to be superior to the above, and was introduced from the north.

Ovens figured largely in sacred rites of the Maori, food being cooked for various ceremonies, such as lifting the *tapu* from persons, houses, land, &c. These ovens seem invariably to be termed either *umu* or *imu* in this district, and never *hangi*, *hapi*, *kopa*,* &c. Certain persons were employed or appointed in former times as kindlers and tenders of these sacred ovens (*umu tapu*). Such persons were termed *takuahi*, and they were thought to be *taunga atua*—*i.e.*, they were

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* *Kopa* = a steam-oven (syn.. *hangi*, *hapi*, &c.). Probably the European term "copper Maori" comes from this name.

mediums, to a certain extent, of the gods whom they served. Theirs was a position much sought after, inasmuch as their peculiar duties afforded them opportunities to acquire the invocations and other knowledge of the priests. So largely did these sacred ovens enter into the life of the people that the term *umu* (with its variant form *imu*) seems to have been used as equivalent to "rite" or "incantation," as *umu hiki, umu pongipongi, imu kirihau, umu pararahi*, &c.

The expressions *tāwhanarua* and *tāmahana* mean to cook a second time—*i.e.*, if when an oven is opened the food is found not to be quite done and so is recooked. In the cooking of birds, however, this was not allowable. If an oven of birds on being opened was found to be underdone the birds would be eaten in that state. To cook them a second time would have the effect of depopulating the tribal forests—the birds would forsake them. You must be careful how you treat the offspring of Tane.

Regarding the Maori oven, as described above, compare a passage in Ossian: "It was on Cromla's shaggy side that Douglas had placed the deer. . . . A hundred youths collect the heath, ten warriors wake the fire, three hundred choose the polish'd stones." A foot-note by the translator states, "The ancient manner of preparing feasts after hunting is handed down by tradition. A pit lined with smooth stones was made, and near it stood a heap of smooth, flat stones of the flint kind. The stones, as well as the pit, were properly heated with heath. Then they laid some venison in the bottom and a stratum of the stones above it, and thus they did alternately till the pit was full. The whole was covered over with heath to confine the steam. Whether this is probable I cannot say, but some pits are shown which the vulgar say were used in that manner." (From "The Battle" scene.)

The terms *tamoe* and *tawhakamoe* mean long in the process of cooking in a *hapi*, as in the cooking of *tawa* berries (*pokere*) and the roots of *Cordyline* (see above). A rite known as *umu tamoe* was performed for the purpose of weakening, unnerving an enemy to render him harmless.

The term *tupuku* is applied to food, such as potatoes, being cooked in baskets, and not placed loose in the oven.

The expression *niho-wera* is applied to a woman who keeps cooking and eating small pieces of food while she works. *Kapekape* is a stick used to rake out embers or food from a fire. *Rorerore* is a stick used as a poker to stir a fire with. *Pinohi*, a bent stick, used as tongs in order to carry hot stones, as in stone-boiling. *Tāngutu* is applied to a big fire or large pieces of firewood—"*Tikina atu he tangutu mo to tatou ahi.*" *Pepeke* is also applied to large pieces of firewood.

A much-used saying here is, "*Mahia he wahie mo takurua, mahia he kai mo tau*"—*i.e.*, "Prepare firewood for the winter, but prepare food for the whole year."

On the coast about Whakatane in former times *pipi* shells and pumice-stone were used as fuel—*i.e.*, placed on a fire of *manuka* to supplement or assist the scanty supply of firewood.

In olden days firewood was broken into the required lengths, hence the expressions *tātā wahie* and *whatiwhati wahie*. Even now some of the old people still use these terms, albeit the steel axe is in use everywhere. A stack of firewood (*wahie*) is termed an *apaapa wahie*. Dry wood was stored in the sleeping-houses as fuel. Slings of *aka*, a tough forest creeper, were secured to the wall of the back end (*tuarongo*) of the house, being some feet above the floor. In these slings the firewood was stacked and so kept suspended. Dried firewood is usually stacked in the cooking-sheds for use there; in fact, the walls are sometimes composed of stacks of fuel.

Having no knowledge of the ceramic art, the Maori utilised wood, gourds, and seaweed from which to fashion vessels to contain liquids. In this district wooden bowls and gourds were used, as we have seen. Also, vessels termed *păpă* and *pātua* were made of *totara* bark, the former to contain *huahua* foods, the latter to contain water, and also used for stone-boiling. Small *pātua** were also made for temporary use (to contain water) of bark of the *puahou* and *mako* trees. These, however, soon shrunk and became useless. *Oko* were bowls made by cutting a gourd in half. *Ipu*, or calabash water-vessels, were sometimes ornamented by carving them, the designs being similar to the *tuhituhi* patterns of house-rafters. The *poha* was a vessel made of seaweed, and in which the *titi*, or mutton-birds, were preserved; but these were only occasionally seen here, being obtained from coast-dwelling people. *Ripa* was another name for the *oko*, or bowl made from a gourd.

When food was taken from the oven it was placed in small baskets woven from leaves (*wha*) of flax, *mauri*, or *kokaha*. These baskets were termed *honae*, *tonae*, *rourou*, *tipoti*, &c. The two latter were sometimes used to cook food in. These rough baskets were simply used once, as plates, and then thrown away. The custom was for several persons to have a basket of food between them, round which they sat and helped themselves with their hands, the *kinaki*, or relish, of birds or fish, &c., being placed on the top of the vegetable

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* *Pātua* is, in Williams's Dictionary, marked with short accent over first "a," but the first syllable is long—at least, in this district.

food, *kumara*, or *taro*, or greens, or potatoes. Persons of importance would often have a basket to themselves, and persons under *tapu* would take their food apart from others. When a person was under a special amount of *tapu*, such as a *tohunga taua*, or chief priest, after he has been engaged in cutting the hair of the sacred *mātāmua*, or first-born of a high family, or a priest who is attending a lying-in woman, then it required several persons to feed that priest, who could not touch cooked food with his hands. One person would prepare the food in a special oven and hand it to another, who bore it to another person, who took it to the person who was appointed to feed the priest (as if the latter were a helpless child). Only this last person would approach the priest; the others kept afar off. At the present time the dishes are used here in which to place the food, and one often sees the dogs joining in the repast. The water in which greens have been boiled is poured into the dish among the food, and each person will lift the dish in his hands and drink of this delightful beverage.

Spits on which food, such as birds, &c., was stuck in order to be roasted are of two kinds. One, termed *huki*, is simply a pointed stick. The other, called a *korapa*, has two points, made by splitting the end of a stick and opening the divided halves out.

Food-stores were formerly an important item in the Maori domestic economy, and the *pātăkă*, or raised storehouses for keeping food in, are too well known to need any description here. Stages or platforms, termed *whata*, were also much used for the same purpose. The elaborately carved storehouses of old were generally used for containing the more prized articles of food, such as *huahua*. *Pataka pu kiore* is an expression applied to storehouses built so that the rat cannot enter them, by placing a broad slab on the top of the posts supporting the floor of the store.

The *whata-a-rangi* is a stage or platform erected in a tree, and is used for storing foods on. The *whata poto* is a stage built on high posts, and used for stacking food-supplies on. It has no house on it, or permanent roof, merely a thatched roof to protect the stores from the rain. The *whata pu kiore* is a stage built on two, four, or six posts, and on which a wooden building of neat and close construction is built. These stores were reached by means of rude ladders (*ara-whata*), usually a log with a series of notches cut therein for steps.

The Maori does not use any implements in eating saving the time-honoured "*Tokorima a Maui*"—*i.e.*, his five fingers. In the case of a person under *tapu*, and hence unable to touch cooked food with his hands, he would either get some person

to feed him or use a pointed stick as a fork to convey the food to his mouth. Such a fork is termed *tirou* or *purou*. Failing these, the food would be placed on the ground before him, and he would gnaw it as a dog would—a very lame dog at that.

We will now proceed to note various customs, rites, sayings, and superstitions as pertaining to food-supplies :—

Kai parapara : When Mahia, of Tuhoe, was slain by Te Whakatohea at Te Pa-puni the food products of the place were placed under *tapu* on account of blue blood having been spilt there. Some of the people disregarded the *tapu* and ate of those foods. That was a *kai parapara*. It was disastrous for the sacrilegious persons, who were slain by Tuhoe, who marched from Te Whaiti, where they had been taming the Pu Taewa, and desolated the Land of the Lost Lake.

The first fruits of birds and fish were offered or fed (*whangaia*) to the gods—*i.e.*, to Tu-nui-a-te-ika, to Maru, and others of the numerous gods of the Tuhoean pantheon. The first fruits of potatoes or other cultivated foods are collected, a few from each home, in the spring, and are taken to the principal village of the district, where the *pure* rite is performed. This lifts the *tapu* from the young crops ; and the collecting of the first fruits is termed the *amoamohanga*. The *tapu* is placed on the crop in midwinter by a rite known among these Hauhaus as the *huamata*, but which was formerly termed the *maara tautane*.

It must ever be borne in mind that cooked food is the very essence of pollution in the eyes of the Maori, and was much more so in the days gone by. Hence meals were eaten in the open or in the *roro* of the houses—*i.e.*, in the deep porch. A chief, or any *tapu* person, not only could not eat his meals in a cooking-shed, but he could not even enter one, nor yet go near it or the ovens where food was prepared. Hence cooked food is always utilised in order to *whakanoa* or lift the *tapu* from persons, things, or places, to make them common. The expression "cooked head" is equivalent to the most degrading and virulent curse, an epithet that has caused much bloodshed in these isles. Another such is *hoa o te kai*, which, though not so virulent an epithet as the foregoing, is yet very insulting, inasmuch as it implies that the person so addressed is the companion or equal of food. The meaning assigned to this expression in Sir G. Grey's "Maori Proverbs," page 85, is not the one generally accepted.

The word *tāmaoa* is often heard here. *Maoa* = cooked ; *ta* is a causative prefix. But in this sense *maoa* or *tamaoatia* means "polluted." In the bird-taking season, should cooked food be taken into the forest, then *kua tamaoatia te ngaherehere* (the forest is polluted)—*i.e.*, the *hau* or sacred

prestige or vital essence of the forest is destroyed, and the result will be disastrous for fowlers, for the birds will desert that forest. It is an offence against Tane, the god of forests and of birds.

No Maori of position could carry cooked food on his back; if he carried it at all it would be in his left hand. The first-born male and female of a family of rank were sometimes kept very *tapu*—allowed neither to carry food nor yet to work. If it was desired to lift the *tapu* (or partially lift it) from such a person, he (or she) would probably carry some of the food to be used in the necessary rite, known as a *purenga*. That act in itself would break down the *tapu*; after which the various sacred ovens of the *pure* rite would be partaken of, the officiating priest repeating the invocation termed *taumaha*. The following is a *taumaha*:—

Taumaha ki runga,
Taumaha ki raro
Taumaha kai te whatu iria,
Kai te whatu rawea
Kai te whatu i nga koromatua,
I nga ruahine.
Ka kai ki tua
Ka kai ki waho
Ka kai ki te rangi nui e tu nei
Ka kai ki te Papa e takoto nei
He ora ki uta, he ora ki tai
He ora ki nga koromatua.

Enough! The rite of *whakanoa*, or rendering common, is completed.

The *whakau* is an invocation repeated over very sacred foods, such as those carried by first-born notables, as described above, or food connected with the dead, or priests, or any sacred place. The *whakau* renders such food *noa*, or common, so that the people who eat of it may not be slain by the sacredness thereof. The borrowed and misleading expression *whakawhetai* is now generally used by these natives to denote the *whakau* and *taumaha*. The priest officiating at the *whakau* rite takes a piece of the food and feeds (offers) it to the gods, repeating—

To kai ihi, to kai ihi
To kai Rangi, to kai Papa
To kai awe, to kai karu
To kai ure pahore
Whakataha ra e te anewa o te rangi
E tu nei
He tawhito to tapu
E homai nei kei taku ure
Na te tapu ihi, na te tapu mana
Hina (hinga) ki mua
Takoto ki raro
Ki to kauwhau ariki.

The priest then lifts the piece of food to his mouth and repeats:—

E kai tatau!
E kai! E kai!
Kai atu tatau ki nga ihi i te rangi
Ki nga mana i te rangi
Ki nga tapu i te rangi
Kauaka e turoua.
Kai atu koe ki te ihi
Kai atu koe ki te mana
Ki nga rua tupapaku
Ki nga rua koiwi
Kauaka e turoua
Mate rourou tiritiria makamaka
Kia kai mai te ati tipua
Kia kai mai te ati tawhito
E kai! E kai!
Kia kai nuku tatau (for tatou)
Kia kai rangi tatau
Kia kai matamua tatau
E horo, E horo o tatau kaki
Takoto ki raro
Ki to kauwhau ariki.

The *whangai* is another kind of *whakau*, and is also connected with food. When persons were about to start on a journey, and were fearful of being bewitched by the people of the lands they were going to travel through, they would cook some food and eat of it. The remains of such food they would place in their belts and so carry with them. That food would ward off any magic spells, &c., which might be directed against the travellers.

When a present of food was received from another tribe or place the superstition and caution of the Maori were in evidence; hence the following ceremony, with its invocations, was performed in order to make common (*pure*) the food, to remove from it the *mana* (power, prestige) of the givers, and to prevent or avert any spells or rites of witchcraft that might have been performed over it.

The food arrives. The priest arises and performs the *takiwhenua*—that is to say, the *pure*. Because the food has come to us on (under the influence of) the *māna* of other peoples. Now, lest disaster assail us. There may be evil influences at work in regard to that food. The priest arises and repeats the *takiwhenua*. *He takiwhenua tenei, he pure* (this is a *takiwhenua*, a making common):—

Ka waere
Ka waere makere ti
Ka waere ki runga o makere ta
Ka waere ki waho o makere ta
Kia haramai makere ti
Kaikai kutu makere ti
Kaikai riha makere ti
Te roua atu, te kapea mai

Roua ki Whiti, roua ki Tonga
E tu te rouroua
E taka te kape
Kapekapea
Ka eke i to ihi
Ka eke i to măna
Te ihi nei, nga tapu nei
Ko tai koki
Ko tai takoto atu ki raro
Nga peruperu mawhawha
Haere ake ra te ihi o nga toa
Tee whatu
Tatea a nuku, tatea a rangi
Huri ana te po, huri ana te ao
Tena te whatu ka rere
Ko te whatu a te pukena (pukenga)
Tau koroki
Ko te whatu a te wananga
Tau koroki
Koa ki runga
Tau koroki
Koa ki waho
Tau koroki
Tena te rakau
Ko tu te rangi
Haruru nga toro
Ko te rakau a kai hika
Te rakau a kai ure
Waerea te maru tuna
Waerea te maru wehi
Haere tarekoreko atu ki tahaki—e-e.

The priest then takes the *ahua* (semblance, likeness, personality, representation) of the food and roasts it at the fire, and then eats it. He then repeats the *taumaha* :—

Taumaha te ihi o te kai
Te măna o te kai
Te maru tuna o te kai
Te maru wehi o te kai
He kai! He kai!
He kai ma kutikuti
He kai ma kapekape
Ka kape i to ihi
Ka kape i to mana
Ka kape i to maru tuna
Ka kape i to maru wehi
Ka kape i to maru korero
Ka kape i to maru wananga
Ka mămă nga pukena (pukenga)
Ka mămă nga wananga
Ka mămă hoki ahau, tenei tauira.

Enough! The people may now eat of the food.

When we hear that travellers are approaching our village we set to work and prepare food for them. When they arrive some one will say to them, "So-and-so is preparing food for you" (*kai te taitai kai a mea ma koutou*). Now, if they do not stop and partake of that food it is an evil

omen for them; they have disregarded Tahu (*kua takahi i a Tahu*). But if those people are in a hurry to proceed on their way it is sufficient if one of them takes a portion of the food, however small, cooked or raw, and eats it. That will avert the evil omen.

Here the food is personified in Tahu (see above), who must not be disregarded or trouble will surely follow.

The remains of food left after a *tapu* person, such as mentioned above, has partaken of a meal are extremely dangerous, and if eaten by any rash or unwary person he will become weak, listless, and good for nothing until he is cured either by the priest or the person whose food he ate. Should this act be committed in war-time, then the offender will be afflicted by *tu-mata-rehurehu*—*i.e.*, he will become faint-hearted and apprehensive, and of no account on the field of battle.

A good way to slay a person by witchcraft (*makutu* or *whaiwhaiā*) is to obtain one of the cooking-stones from his oven and take it to a competent wizard, asking him to repeat a spell over it. Have this stone returned to the oven of your enemy and await results. Any one eating of food cooked in that oven will know death. Another method of bewitching a person through the agency of food is known as *mātākai*. It has been fully explained in a former paper.

The following is a charm repeated over a person who is choking. The person is slapped on the back while the words are being said:—

Kaitoa ano koe kia raoa
Nau ka ngau mai, ngau mai
Nau ka ngau atu, ngau atu
Te horo a te kawau
Horo mania, horo panuku
Puwhaina mai ki waho.

Here is another charm for choking. It comes under the generic term of *whai*:—

Te whai
Whiti raoa, tapa raoa
Kaitoa koe kia raoa
Na to kai tu, na to kai rere
Na to kai haere
Na to kai tama wahine
E hia ou kai?
E rua ou kai
I horomia e koe
Ko nini, ko nana
Ko te patari o Wahieroa
Tama wahine, whakaruakina
Raoa ki waho
Hokaikai ana ou ringaringa
Hokaikai ana ou waewae
Hotu nuku, hotu rangi
Hotu pakia
Whakaruakina!
Nau mai ki waho.

It is said that food products could be destroyed—*i.e.*, lands rendered unfertile—by means of magic rites in former days. A charm or incantation termed *papa-hāro* or *te tipi a Houmea* was used for the above purpose.

When going to visit another village it is bad form to go empty-handed (*kaore e pai kia haere ko te rae anake*); better take some article of food for the people you are about to visit. It disarms the critical and prevents sarcastic remarks being made. Such an offering is termed a *puapua* or *koparepare*. Visitors to my 8 ft. by 10 ft. mansion often apologize for not bringing a *puapua*.

Omens, Superstitions, &c., pertaining to Food.—It is an evil omen (*ăituā*) to omit a person in the apportionment of food at feasts, &c. You must be very careful never to let a wizard become possessed of a portion of your food, for if he does he holds your life in the hollow of his hand, and can destroy you by his magic arts, using the food as a medium for his charms, for that food contains, or is imbued with, a certain amount of your personality. Hence the danger.

When a marching war party halt to cook food they must be careful to divide and scatter the *koronae*, or leaves used to line the oven, ere they lift the trail again. Neglect this and trouble lies before them. To find a lizard (*moko tapiri* or the *moko kakariki*) in an oven or in a dish of food is an evil omen. Certain nights of the moon are reckoned unlucky for eel-fishing or planting crops. The following list of the nights of the moon shows the unlucky nights marked with a cross. This list was sent to me by Mr. G. H. Davies, and was collected from Wi Tana Papahia, of Hokianga:—

x Whiro (new moon).
x Tireo.
Hoahoata.
Ono.
x Tama teangana.
x Tamatea.
Tamateaio (quarter).
Tama te Whakapau.
x Te Huna.
x Te Ari.
Te Hotu.
Te Mawharu.
x Atua.
Ohua.
Oturu (full moon).
Rakaunui.
x Rakau-matohi.
Takorau.
x Korekore.
Korekore-tutua.
Korekore-whakapiri (quarter).
Tangaroa a mua.
Tangaroa a roto.
Tangaroa-kiekie.
x Tangaroa-whakapau.
x Otane.
Orongonui.
x Maure.
Mutuwhenua.
Hui-te-rangi-ora.

Sayings and proverbs regarding food are innumerable. We give a few specimens of them:—

"*Kotahi ou kai, kotahi ou tangata*" (One food, one person—you have only provided food for yourself and none for your companion).

"*Kaua e huirangitia te kai, engari e tau ki raro*" (Do not eat standing; sit down to your meal). It is an evil omen for a war party on the march to eat standing.

"*Te kai a te waewae e kimi*" (When in travelling we chance upon food our legs found it for us).

"*Nga uri o Mahanga whakarere kai, whakarere waka*" (The offspring of Mahanga, who abandoned food and canoe). Mahanga was having a canoe made at Raorao-totara, near Mount Edgecumbe, and the canoe was shattered by an accident, which so disgusted Mahanga that he left his canoe and his meal and at once migrated north, nor did he ever return.

"*Waiho i kona nga tama a te ngahuru haere ai*" (Let the offspring of the autumn alone to stroll about as he likes). The sons of Koira of old used to absent themselves from home when work was toward in the planting season, but when the crops were gathered they returned to where food was plentiful. Some one asked Koira why his sons did not assist him in his labours, and he made the above reply.

"*E whai i muri i a Rehua, kia kai ai koe i te kai*" (Follow after Rehua that you may obtain plenty of food. When travelling always join a chief's party and you will fare well).

"*Haere i raro i te kaahu korako*" (Travel under the wing of the white hawk). A similar saying to the foregoing one.

To a person who turns up his nose at the food before him we say, "*E kore te kino kai e whai ki te pai tangata; ko te pai tangata e whai ki te kino kai.*"

"*Ehara ta te tangata kai, he kai titongi kaki; e kore e rite ki tana ake, tino kai, tino makona*" (The eating of other people's food merely tickles the palate, but that gained by our own exertion is best and most satisfying).

"*Kai hoki i Waiaua ra*" (There is food also at Wai-aua. I won't stay to eat with you, but push on to my destination before I eat).

"*Tu ana rae roa, noho ana rae poto*" (When visitors arrive the meal will be over).

"*He waru ki runga, he rare ki raro*" (Summer above, indolence below).

"*Kai kino ana a Te Arahe.*" Te Arahe was a person who used to store up dainties and eat them in secret that she might not have to share them. Hence when any one acts in that manner we say, "Te Ara-he is eating in secret."

"*He oneone to puku?*" (Is your stomach like the earth

that it cannot be filled with food). Said to one who complains of the long time taken in preparing food. "It will be here in good time. Food has no legs wherewith to run away."

"*He taua ano to te kai*" (Food can conquer man, as well as an armed foe can). Said to those who want food quickly and in plenty. When much is placed before them they cannot eat it all.

"*E tama E! Mo a muri, mo a nehe*" (O, son! The days that lie before will avenge this). Said to a person who refuses one food. Some day he may be in want of food.

"*Kai ana mai koe he atua, noho ana ahau he tangata*" (You are eating there like a god; I am sitting here as an ordinary man). Said to a person who does not offer to share his meal with another. "You appear to despise me, but I may slay you by magic as you eat."

"*He kuri, he tangata haere, kaore ona tikanga, ona aha*" (A traveller is like a dog, of no account whatever. Any food is welcome to a traveller; do not trouble to prepare choice foods).

"*Na tetahi a Maui ka ware ore, ka tata hoki.*" Said when people get tired of waiting for coming guests and so eat the food; then the visitors arrive when the food is consumed. It was a thoughtless act when the guests were so near.

"*He toki kai runga, he toki kai raro*" (Two sets of sharp teeth to eat the food with. Never mind if it be underdone).

"*Kai te waro o te rehunga*" (It has gone down the red lane—of food that has been consumed. It has disappeared down the gullet). This saying is also applied to land.

"*Ko Putauaki te kainga, he ngarara tona kai*" (Lizards are the food at Putauaki). Food-supplies were not numerous at Mount Edgecumbe.

"*He aha ra a uta i ora ai*" (How can inland tribes fare well? They have no fish or products of the ocean for a change of diet).

"*Hohonu kaki, papaku uaua,*" or "*Hohonu korokoro, papaku uaua*" (Deep throat, shallow muscle). Applied to a person who is a good trencherman, but is absent when work is toward.

"*Whakaha kau ana a Whakarau*" (Whakarau gets only the savour of the food. When he arrived the food had been consumed). Used under similar circumstances.

"*Ka pou te kai, ka noho te rae tangata*" (When visitors arrive the choice foods have been consumed). The coming visitors banished those foods. This is a singular belief—the *mana* of approaching visitors banishes food—*i.e.*, birds, &c., will not be obtainable; they will not enter the snare, &c.

"*Ka hoki te rae tangata, ka hira te rae kai.*" Food has been prepared for a certain expected guest, but another visitor

arrives before him. We cannot give the choice foods to the latter because they were prepared for another. Hence the above remark.

"*Tu pupu, tu ngaro; tu kete, tu ea.*" Some food is taken, as a present, to a village and handed over to the principal person thereof. He distributes part of it among the people. Who knows that any return present will be made by those people for what they have received? But the chief is sure to make a return present for the portion retained by him.

"*He tutanga te unuhia.*" Applied to those who are industrious and energetic in digging fern-root, and other labours.

"*He tutae koinokoino (koingoingo).*" Applied to bird-snarers and fowlers generally. Those who depend solely upon birds as a relish for their food are liable to go short at times. Birds are scarce during some seasons.

"*He toa taua, he toa e waia; he toa ahuwhenua, he toa tuturu*" (The cultivator of the soil is a greater man than the warrior).

"*Te whatu o Poutini*" is an expression applied to berries of the *hinau*.

However, we will discontinue these sayings. They are so numerous that it will be better to compile a separate paper on the proverbial sayings and apophthegms of the Maori in the days that lie before.

We insert a few expressions, as applying to food and food-supplies, some of which are not commonly heard:—

Hahore—"*He whenua hahore*": A sterile land, not productive in food-supplies.

Hunua: Same meaning as above. Applied to high ranges where birds are scarce on account of the lack of *toromiro*, *maire*, and *kakikatea* trees.

Kumanga-iti—"*He tangata kumanga-iti*": A sparing eater.

Koto: Having a dislike to certain food. "*He koto a mea tangata ki te kai nei!*"

Ihu oneone: Dirty nose. Applied to a person industrious at cultivating food. The terms *ihupuku* and *puku-mahi* denote industry, as also does *ringa mahana*.

Tangata marae: This term implies a generous person of a hospitable disposition.

Uruora: Applied to forests in the valleys and lower ranges, where birds are plentiful on account of there being plenty of berry-bearing trees, as the *toromiro*.

Whenua pua: Land where there are plenty of berries for birds.

Many of the *waiata Maori*, or native songs, have reference to food. A few examples are given:—

He Waiata.—Na Hara, Mona i korerotia ki te matapiko ki te kai (a Song, by Hara, who was accused of Inhospitality).

E whae E!
Kaore e kitea e au te mata mau
Kati ano ki ahau ko te korero
Ko te waha tarera ka rua
Takiri mai koia ko te ata
Na runga mai o nga puke ra
He aha te kai mau ra tia e au
He uhi, he taro,
Ka taka te piko o te whakairo
Ko te kai onamata he hinu ra,
He mimiha, he pakake ra
Ko te kai a te tipua, he wai *rama*
He nanua pounamu kai te moana ra.

To be accused of meanness as to food is quite a serious affair to the Maori. The above song was composed in the early part of last century, when Europeans were termed *tipua*, or demons, and rum was supposed to be an important part of their food-supply.

The following song was composed by one Parepare, who was accused of secretly eating the stored foods of the village :—

He aha kai taku ihu
He whiti tamaki nei au pea—e
Mauria atu ano
Engari kia ata pakia atu
Ko Herapeka ko te ki mai
Ki te kaia, ki te tumatarau
Te kai hunahuna
Te kai whai ki to ringa
Kaore mai mua i nga pakeke
Katahi nei ka pakia e koe
Ki muri nei
Ma te hauauru, mana e hari atu
Ka whakarangona atu Erueti i waho ra
Ki aku rongo kai kino
Tenei kai ahau hai paki ware
Ma Ngati-Tahu—e-i-e
Kauaka hai tupou kia haramai ki runga ra.

The Maori mind was ever richly stored with ideas of a metaphysical nature; it teemed with personifications and metaphor. His language abounded in emblematical expressions and quaint Old-World conceits. Hence we always see in the primitive myths of the Maori a desire to locate the causality of things, to explain the origin of matter. In regard to food, we have seen that the origins of the gourd and fern-root have been personified, as the *kumara*, or sweet potato, is represented by Rongo and Pani. In like manner these natives have a generic personification for food in Tahu, who is said to be the parent or origin of food. By some tribes Tahu is said to have been a brother of Rongo. Tahu emblemises good. A common saying among Tuhoe is, "*Kaua e takahi*

i a Tahu"—*i.e.*, Do not disregard Tahu. This remark is made when a person refuses proffered food. In Sir G. Grey's "Maori Proverbs," page 85, we find the expression, "*Te inati o Tahu*" as applied to woman, whereas men were the sons of Tu, the war-god.

Hakari (Feasts).

In former times these *hakari*, or feasts, were important features of the domestic life of the Maori, and formed one of their most striking social customs. At these functions the different tribal divisions met together and topics affecting the welfare of the tribe were discussed, thus helping, to a certain extent, to bind together the various family groups of these jealous communities. Outside tribes were also invited sometimes to these feasts, and probably the only bad effect of these meetings was the scarcity of food which usually followed them. A feast was held when the *kumara* (sweet potato) crop was taken up and stored, and among the mountaineers of Tuhoeland a like function was observed when certain rites were performed over the first fruits of the season—*i.e.*, of birds and fresh-water fish. Feasts were also held on the occasion of the marriage of important people, and on many other occasions. Names were given to feasts of importance, such as Hiwanawana, a feast held at Otairi, near Te Whaiti, where the Ngati-Rongo and Tuhoe Tribes were guests of the Patu-heuheu people.

When arrangements had been made for giving a feast messengers were despatched to invite the guests. These messengers were called *whakareka*, and consisted of a *ti ngahuru*, or party of ten persons, or some such number.

Meanwhile the givers of the feast have been busily engaged in preparing food and accommodation for the coming visitors. Huge stages were constructed on a scaffolding of poles, and sometimes having several floors or stages. On these food was piled and hung. Also long rows of food in baskets were stacked on the ground, and at intervals poles were set up in these rows. I have seen such poles bedecked with one-pound and even five-pound notes, all of which, together with the stacks of food, were handed over to the guests. That was at Turanga, about the middle "seventies."

The stages for stacking food on were termed *whata*, and were sometimes of great size. *Kumara*, *taro*, berries, birds, fish, and other foods would be provided in abundance. Calabashes full of birds and rats, preserved as already explained, occupied an important position. They were the centre-pieces of the feast, and were ornamented after the manner of the Maori. Mounted on carved wooden legs, and covered with a piece of woven matting adorned with bunches

of feathers, and topped with a hollow top or mouthpiece of carved wood, they presented quite a brave show. To the top part of the netting covering the calabash were attached six or eight loops of cord, which were drawn up over the lid and secured.

But the invited guests have lifted the trail of Tahu, and we must prepare for them. When the party is within a day's march of the village a party meets them, bearing a present of food. They will meet the visitors at their last camping-place before arriving at the place where the feast is to be. This is termed a *tu-mahana* or *pongaihu*.

When the party arrives at the village they do not at once come right up to the ground where the *hakari* is to be held, but halt some little distance away. One person then advances from among them, and, walking up to the first pole, set up at the head of the row of food, he stamps his foot at the base of the pole and repeats to himself the following incantation, but not so as to be heard :—

Ka takahi ki runga,
Ka takahi ki raro
Ka takahi ki uta
Ka takahi ki tai
Ka takahi ki raro
Ki te po wherikoriko
Ngaro ki uta
Ngaro ki tai
Ngaro ki tupua
Ngaro ki tawhito
Mau ka oti atu,
Oti atu.

This singular act is termed a *whakarori (ka takahi i te upoko o te kai, hai whakarori i te kai kia rori; ara, he whakanoa)*; it lifts the *tapu* from the food, and, were it neglected, the omission would be a *kopare* (an evil omen)—that is to say, if the visiting party did not halt to perform this act, but marched right on to the reception-ground. The saying "*Ko Tahu kia roria*" is applied to the above ceremony, for Tahu is, as we have seen, the personification of food.

The above incantation is directed against the food supplied for the feast, and the food products generally of the place (*hai whakarewa i te kai*). The priest of the village community will then proceed to recite the following charm or invocation, termed a *whakararau*, and which is intended to paralyse the effects of the first spell and retain the food products of the place, their vitality, &c. :—

Puritia
Puritia a uta
Puritia a tai
Koia puritia, koia tawhia
Tawhia ki tamoremore nui no Papa
He aio tua raharaha.

As a party of visitors march slowly on to the reception-ground they are welcomed with loud cries and the waving of garments, the old women being the principal performers. Were it an *uhunga*, or mourning party, a doleful *tangi*, or wailing, would be indulged in. The leading chiefs of the village stand forth, one after another, and greet and welcome the guests, and *whakatau*, or "settle," them. Then a kind of master of ceremonies appears, with a rod in hand, and proceeds to apportion the divisions of the rows of heaped-up food among the various sub-tribes or family groups of the visiting peoples, calling out in a loud voice, "This is for such a clan," and indicating with his wand the portion for them. The long heaps of food are termed *tahuaroa*.

After the above ceremony a procession of food-bearers appears, bringing baskets of cooked food for the first meal of the visitors. They march slowly on to the ground, generally two abreast, bearing the baskets of food in their hands before them, and often waving them to and fro in time to a song chaunted by the bearers. These songs are known as *waiata heriheri kai* or *waiata makamaka kaihaukai*. When this food is placed on the ground before the guests, then is seen the custom known as *whakatomo* or *kokomo*. Any person who has a relative or close friend among the visitors may have prepared for him some special and choice food, which same he now places before him for his own private use. After the meal is over speech-making on various topics is indulged in by the leading men of both parties, after which each tribal division of the guests retires to the quarters assigned to it, the people bearing with them the *tahua*, or heap of food, which has been given to them.

When the divisions of food (*tahua*) are apportioned to the visitors it may strike the latter that some precautionary measure may be advisable, inasmuch as some evilly disposed person of the place may have bewitched the food in order to destroy the visiting people. So a leading man of the latter will take a small portion of food from each *tahua* and eat the same, in order to avert any spells of magic. Or, if you like not that plan, here is another way: The head of a row of food at these feasts is termed the *kauru* or *upoko*—*i.e.*, the right-hand end of the row as placed before and seen by the visitors. The left-hand end of the row is termed the *take*. When the food has been presented, but before any of it is touched, a priest or elder rises from among the visitors and, taking the basket of food which is at the extreme end of the *kauru*, he carries it to the *take* and there deposits it, taking also the basket from that end and depositing it at the head of the row. This act is a *whiti ora*, and it will avert all troubles,

evil omens, and other danger to which the superstitious Maori was ever exposed, or believed himself so to be. I have heard of another local custom in which the first *rourou*, or basket of cooked food, brought by the food-bearers is placed before the priest of the local people, who places himself at the *upoko*, or head of the feast—at the head of the table, in fact—albeit the table is, and was ever, the broad bosom of Mother Earth.

We will now give a few of the songs as sung by the food-bearers above mentioned :—

He Puha Heriheri Kai (a Food-carrying Chaunt).

He kumara kai hamuhamu
Ko te ehu o te kupu nei na
Kia hoki kau atu ina
Te tina ki taia mai
Ka mate taia mai
Kahorehore!
Kahorehore!
Ka mate te puke e tu iho nei
Kahorehore!
Kahorehore!
He kotahi te kete
I kimihia ki te kore
Kore rawa aku iwi ki te mahi kai—e.

This song contains a good example of the difficulties which are encountered by those who attempt to translate Maori songs, incantations, &c. The word *ehu*, in the second line, might well puzzle a pundit; but it is used for *ahua* on account of its being more euphonious to the Maori ear in that place. If *ahua* was used it would spoil the euphony (*ara, kua huatau*). Here is another of the songs :—

Whakatutu kau au i taku kete
Pahao kau au i taku kete
Te mareretanga o te tui
Kokopu ki te wai
Pao (pohu) potehe
Potehe te kai ki raro
Ki te whenua
Potehe!

He Waiata Makamaka Kaihaukai (Na Ruru, he karakia kia kore e kaha tana hoa makamaka kaihaukai, kia hinga i a ia. Composed and sung by Ruru. An Incantation to destroy the Powers, Agility, &c., of his Companion in bearing Food).

Korokoro whiti!
Korokoro whiti!
Tu ana te manu i runga i nga puke ra
Tenei hoki te kame ka whakairi
Te kame ka whakarere
Te kame i pokaia noatia
I runga i a Tu-ka-riri
I a Tu kaniwha,
I a Tu-ka-ritarita
E haere ana a Rita
He tangata kamenga kore
Ka pau te ki hanga maka

He nui kame maoa e tu ana
I o atua roa
He tini te kame, he mano te kame
He tutae taua
Ka kame tiko iho ki waenga
He aha aku kai tee pau noa ai
Naku te tohenga ki te whitu, ki te waru
Ki te roa o te tau.
Waiho nei matau hai timokomoko kai
Ma te ngahuru
Tangi ana te whakatopatopa o kame,
O kame maunu
He toroa! he taiko!—e.

Whiti Tuarua (Second Part).

Ara e hau mate kino o te whakaangiangi
Nohoanga roa i te taha o te kame
Na ka pa tahau, he iti mai ano na Mouhanga
Koia ra ia e tohea ake nei ko te takahanga
Kia ata kitea iho e roa te tau
Naku i whakanui, naku i whakakake
Kia kake mai ki runga ra
Kakekake mai i o manu
Ki tetahi taha o te wairangi
Tu te rupe, rau te kawa
Ko te kawa i herea
Ko te kawa i a matua nei
Koukou ruru—e mata taitaia
Ka tukia te papa i raro nei
Ko ou tahi taua o mua iho ra hoki
Houhanga rongo, maunga rongo noa ki konei
Houhia kautia ki te kakaritanga
O te uri o Tiki.
He aha te kame ma kuku, ma kaka
Ma koroiriawa
Ma kau hoehoe mai tarawahi awa
Nana te toki i kotia ai te pane o nga poaka
Ehara i te peka i whawhe mai ano
Tauwhitu kia matau nei
Tirohia atu he takahanga ma tai rau
E tikoki ana, e mau ana kiki wara
Ka mahue pinara
I whakangongotu ai papa oku ki te mate
Tohu tonu o matau mate
Na Tiki, na Ponga, koi homai
Ripaia mai ra o tekateka ki konei
I hea i raru ai au na—i.

Such were the feasts given, sometimes on account of war, or of a peacemaking, or in order to discuss some other important matter. The people to whom the feast was given will endeavour to give a return feast, and will work hard to grow or provide food for the same. The term *paremata* was applied either to this return feast or to a present, as food, taken by guests and given to the givers of the feast. In the modern Hauhau religion of these natives the term *paremata* is applied to the money subscription collected for feasts at the performing of the *huamata* and other rites.

When the people were gathered at these meetings the brighter side of the social life of the Maori was seen, and many games and amusements were indulged in, the *whare tapere* was largely patronised; but such amusements have already been described in a former paper.

Here is another account of the arrival of guests and the performance of the *ue:* "A house is built for a *kaihaukai* (feast). The invited guests arrive and enter the house. The people of the village are collected outside, and are seated watching the visitors. The priest of the visiting party clambers up on to the roof of the house and recites the *ue* incantation. When he repeats the final words, *Hui e! taiki e!* his party, who are seated against the walls inside the house, all join in this chorus, and, seizing the uprights of the house, endeavour by united effort to shake the building. If any part of the house gives way that is an evil omen for the hosts; they will take no further interest in the meeting or feast—*kua hiki o ratou mahara*—their minds are unsettled by the occurrence."

The following account of the *ue* was given to me by a member of the Ngati-Awa Tribe. It does not agree with the Tuhoe account, but does so with a description given in "Te Ika a Maui," page 343, 2nd ed.

A *hakari* messenger to the people. As he approaches the village (of those he has come to invite to the feast), and before he has entered it, he chaunts the *ue* :—

Uea!
Uea i te poupou o te whare
Uea i te pou tuarongo o te whare
Kia tutangatanga
Nau mai!
E waha i taku tua
Ka haere taua
He karere hakari
He karere kaihaukai.

As he finishes his chaunting of the above the people of the village reply with the following, which is, in the first place, an invocation to protect themselves and their food products from possible magic arts; and, in the second place, a declining of the invitation :—

Whenua a uta
Kai a puritia
Whenua a tai
Kai a puritia
Puritia ki tamoremore nui no Papa
He aio
E kore au e tae atu.

The inviting messenger then chaunts :—

Tuia ko te kawe runga
Ko te kawe o te haere.

To which the villagers reply :—

Kaore au e tae atu
Kaore aku paremata
E haere atu ai au.

Turanga hapa : When people are busy preparing food for visitors, should any person or persons absent themselves from the task that is termed a *turanga hapa.* "*Au mahi a te turanga hapa !*" is a belittling expression applied to such people.

Inati and *tuhanga :* Terms applied to small lots of food, as the portion for a single person. The expressions *tahua* and *tahuaroa* are applied only to large lots, as the long heaps at a *hakari.*

The plumes of the *kotuku* (white crane) were highly prized by the natives. These birds used formerly to breed, it is said, at a lagoon or pond at Manuoha. The plumes were *tapu,* however, and if a man wearing the same be eating no woman may join in the meal unless the wearer of the plumes takes them off and lays them aside. Were a woman to persist in joining in the meal her hair would all come out and leave her hairless.

Matariki (the Pleiades) was depended upon by the Maori for the signs of the coming season as to whether food-supplies would be plentiful or not. If the stars of *Matariki* appear wide apart, then a warm, plentiful season follows; if they appear close together, a cold, foodless season follows.

Rehua (? Antares) has two wives. One is Ruuhi, also known as Peke-hawani (? Spica, in Virgo), the star which marks the eighth month of the Maori year. When Rehua goes to live with Ruuhi the latter places her feet upon the earth, the left foot first, and then the fruits of earth are formed. When Rehua marries his other wife, termed Whakaonge-kai (a star), then summer is upon us. This latter female is a destroyer of food; food becomes scarce (among a forest-dwelling people), whereas Ruuhi provides food for man. When man becomes listless, enervated, it is said that he is assailed by Rehua—that is to say, by Whakaonge-kai—and the heat of the sun.

Heoi ! The list of the foods of the bushmen of Tuhoeland is now completed, or so far as my notes extend. Albeit they may not be complete, yet has it cost much time to collect them—much time and a great patience, long evenings in conversation with the older generation of natives, many tramps through the realm of Tane, long talks by ruddy camp-fires; and primitive man marvels greatly, and says, "What does this white man want to know these things for? What is he going to do? Is he mad?"

It may seem that I have given many trivial details in this paper, but I have been led to do so by a strong desire on my

part to place on record all that is possible about the Maori, and, above all, to illustrate as far as possible my favourite study—viz., the inner workings of the mind of primitive man.

Supplementary Notes.

Cannibalism.—Probably one of the final acts of cannibalism in this district was at the fall of Te Tumu *pa* in 1836. Taurua, Te Kowhai, Te Rua-o-kahukura II., and others of Tuhoe, took part in the storming of Te Tumu. Hikairo, of Te Arawa, came here to ask for assistance, and a party was raised. Taurua brought back to Maungapohatu a calabash containing the flesh of Hikareia. Another, containing the flesh of Te Rua-taha-pari, was brought to Rua-tahuna.

Harakeke.—The variety of flax of which the bases of the leaves were eaten resembled the *awanga* variety in appearance.

Hue.—*Upoko-taupo*, *Whakahau-mātua*,* and *Manuka-roa*† are names of varieties. The first two leaves put forth by the plant are termed *rau kakano* (seed leaves). The term *rautara* is applied to the third leaf, and *putaihinu* to the fourth. When the young runner appears the expression *uma* is used. For some reason the four stars known as Pi-a-wai are called a *hue*.

Kekerewai and *Tutaeruru.*—These are quite distinct. The latter flies about in the evening, making a booming sound. The term *manu a Rehua*, however, applies to both, and they were both eaten. Some kinds of *purerehua* (moths) were also eaten.

Para taro.—The correct name is *taro para*. It grows in the bush, and the edible tubers(?) form a clump. They are like *taro* in appearance, and were cooked for a long time in a steam-oven.

Tōī.—The tap-root of the *toi* (*Cordyline indivisa*) was eaten formerly, as also the young undeveloped leaves. The trunk, or the upper portion of it, was likewise used as food, the outside part being first chipped with stone adzes. All species of *Cordyline* provided food. The young leaves of the *ti kouka* contain a bitter sap, which is absent in the *toi*. The *ti para* was the best eating, and did not require the outside chipped off. The tap-root (*more*), young leaves (*rito*), and upper part of trunk were all eaten. It is not the same as the *ti tawhiti*. Of the *ti kapu* the *rito* alone was eaten.

Ongaonga.—This is worrying me, and is not yet clear. The plant known as *ongaonga* (? *Urtica ferox*) is a plant of the

* Used for *taha huahua*.
† Used for *oko* bowls.

nettle kind, which I have seen about 8 ft. in height. It loses its leaves in the winter. The natives believe that this grows into the large tree known as *houhi ongaonga*, of which the inner bark was eaten in times of scarcity; also that it loses its spines when in the tree stage. Now, I know the tree; it is the *houhi* with short rounded leaves and thick bark, not the one having long narrow leaves. I have no faith in the Maori theory. The *ongaonga* (nettle shrub) has no leaves now (August). Its branchlets are extremely tough. The tree, *houhi ongaonga*, has a few leaves remaining at this time of the year, but most of them have fallen. But the *houhi* with narrow leaves flourishes the year round covered with leaves.

Puruhi.—An old native informs me that this term is applied to leaves eaten by birds. The pigeon eats the leaves of the *kowhai*, *akaaka*, and *houhi* (both kinds), and its flesh is poor eating at such times. Hence the term *puruhi* is applied to all these leaves—"*He kereru kai puruhi, kaore e momona, a ka haunga hoki nga kiko*" (*Puruhi*-eating pigeons are poor in condition and their flesh is offensive).

A kind of worm termed *ngaio* is sometimes found in the *kokopu* fish, and also in the entrails of the *kākā* bird. These birds are thin when afflicted by this parasite.

ART. VI.—*Notes on a Bone Pendant in the Form of a Lizard(?), found on the Sandhills at Wainui; and on some other Bone Objects.*

By A. HAMILTON.

[*Read before the Otago Institute, 11th November, 1902.*]

Plates VIII.-IX.

THE sand-dunes which form the littoral of a large part of the coast of New Zealand have been very prolific in relics of the ancient life of the Maori, as in all suitable places there were settlements from which the fishers went forth to reap the harvest of the sea and to contribute towards the support of the tribe. For miles and miles, especially in the North Island of New Zealand, the winds disclose among the sandhills the middens of old kaingas, and as the wanderings of cattle and the traffic over the sandhills increased, the binding grasses and sedges were destroyed, so that sandhills which have stood for centuries move on and perhaps disclose the remains of habitations of which the names and history have been utterly lost. Many of the relics thus uncovered are soon destroyed by the action of either the sun or the frost, or they may be again covered by the shifting sands. The more common things to be found in the neighbourhood of

old settlements are bone mat-pins, bone barbs of fish-hooks, bone barbs for bird or fish spears, and stone implements; but occasionally a rare jewel is found, lost perhaps in the loose sand by its sorrowing owner who shall say how many years ago. The subject of the present note is a bone pendant or ornament in the form of a lizard. At least, that is what I consider it to be, notwithstanding that the shape of the tail is unlike that of any kind of lizard known to me. It does not even represent a lizard that has lost its tail, as in that case it would be more truncate and not carefully finished off. Judging by the beautifully worked arrangement for suspension, it was made to hang head downwards. It is cut from a fairly dense fragment of a whale's bone. The extreme length is 111 mm. (about 4¼ in.), and the greatest diameter of the body is 32 mm. (about 1¼ in.). The character of the workmanship is shown in the accompanying plate. From the snout to the end of the tail, along the central line of the back, is a row of small notches. It is perfect in all its parts, and is, so far as I know, unique.

The use of a lizard-form as a personal ornament amongst a Maori people must have been rare, as in most cases all kinds of *ngarara* were regarded with horror and aversion. The subject of the use of the lizard in ornamentations and on ethnographical objects by the Malays and Polynesians has been the subject of inquiry by many ethnologists.* Shortland mentions that the small green lizard was held in great awe, because *atuas* were believed to enter very frequently into their bodies when visiting the earth for the purpose of communicating their advice to mortals.† Assuming this to be so, one specimen might have been the god-medium of some old priest, in the same way as the god-sticks were used on the west coast of the North Island. To the average Maori it was sufficient to show him a lizard in a bottle to put to flight the most doughty warrior, as Angas relates in an amusing passage.

In Melanesia and Micronesia the lizard is usually regarded as the incarnation of a god or spirit. Lizards are sometimes found carved on the slabs of a Maori house, but not often. They appear more frequently in the old cave paintings in the South Island.

Bone Needles.

I have received from Mr. Bendall, of the Mahia, at the northern end of Hawke's Bay, some fragments of a bone needle beautifully carved, which was picked up on the middens

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* See D'Estrey, "Étude Ethnographique sur le lézard chez les peuples Malais et Polynesiens," in L'Anthrop., 1892, tom. iii., No. 6; and Giglioli, "La Lacertola," Arch. per l'Antropolog. e la Etnol., 1889.

† Shortland, Trad. and Superstitions of the N.Z., p. 58.

which line the shores of the sandy neck of land which joins the Mahia Peninsula to the mainland and separates Poverty Bay from Hawke's Bay. The material used is human bone, probably a portion of the femur. It has been rubbed down to form a needle originally about 10 in. long, nearly $\frac{3}{4}$ in. wide, and about $\frac{1}{4}$ in. thick. As usual in these needles, only one surface is carved, but the carving is deep, the cuts true and sharp-edged. Fortunately, I happen to have a photograph of a perfect specimen which is in the collection of Major-General Robley in England, and the pattern is so similar that they might have been made by the same artist. They are usually designated "thatching-needles," but I think it more probable that these highly ornamented ones were for ceremonial use, such as stringing the first fruits of a fishing season, to be laid as an offering at the shrine of Tangaroa. Whatever their use, the workmanship is a fresh proof of the artistic capabilities of the Maori race in the days of old.

The length of Major Robley's specimen is $12\frac{1}{4}$ in. It will be noticed that there are two holes through which the cord is attached. This is characteristic of this kind of bone needle. Even the plain ones actually in use for passing the cords that tie on the bundles of reeds or grass to the roof-timbers of a house have these two holes. The specimen on the left of the plate is less elaborate, and has three openings at the top for the attachment of the cord. The number of holes not only affords a more secure fastening for the short cord which was permanently attached to the needle, but, by distributing the strain, lessens the chance of fracture. The binding-cord was attached to the cord on the needle by a temporary hitch, and was cast loose when drawn through.

ART. VII.—*On a Stone Relic found at Orepuki, Southland.*

By A. HAMILTON.

[*Read before the Otago Institute, 11th November, 1902.*]

Plate X.

A VERY remarkable stone relic has been found at Orepuki, a small township on the shores of Foveaux Strait, in the extreme south of New Zealand. In this neighbourhood there are at the present time a few of the surviving Maori people of the South Island, living at Colac Bay and other small settlements. Just opposite, in the western entrance to the strait, is the

Island of Rarotoki, or Rarotonga, which tradition states was named after a Rarotonga of the olden time far away in the Pacific. It has always been regarded as a sacred island, and from time to time numbers of curious specimens have been found on the sandhills and the sites of old dwellings. The European name of the island is Centre Island.

The specimen which, by the kindness of Mr. Dunlop, the manager of the Orepuki Shale-oil Works, I am permitted to describe was ploughed up by a farmer a few years ago. It is made of a dark-coloured slaty stone, and has been carefully worked into the shape of the handle and guard of a dagger or small sword, and then covered with elaborate carvings in low relief. Unfortunately, it has been much damaged, a large fragment being split off from each side. Fortunately, however, the portions destroyed are recoverable by comparing the opposite sides, as the design is repeated as nearly as possible on each side, so that the whole of the design intended to be represented can be recovered. It measures about 92 mm. in length and 66 mm. in width. It is thus too small to be used as a dagger or weapon of offence, though the shape at once suggests such a purpose. The cross hilt is recurved with a fine bold sweep, and the general outline is well proportioned and elegant. There is also a large hole drilled near the butt, which has been bored from each side by a Polynesian drill somewhat unsteady in its action. Beyond the butt or handle and the cross-piece where the blade of a sword or dagger would come is the fragment of a shaft, circular in section, 20 mm. in diameter. It is, of course, impossible to say what length this part was originally—certainly not more than 6 in., probably less. It is also uncertain whether it preserved the same diameter or whether it tapered. There is no indication of tapering on the fragment remaining. The form of the cross-piece has been attained by drilling out a hole on each side of the haft.

Curious as the shape is, the ornamentation with which the stone is covered is still more interesting. The design is formed by cutting out portions of the surface, leaving the lines of the design in low relief. The chief figure is best seen by placing the hole, which is evidently made for the purpose of suspending the object, uppermost. It will then be noticed that the edge of the hole is bordered by a line which projects vertically at the top and which is joined at the bottom to another line forming part of the margin of a lozenge- or kite-shaped face. The line of the face is continued parallel with the first to the top of the hole and stops against the vertical line; above this second line is a third which only comes half-way down and then merges into the ornamentation of the sides. The inner line is carefully notched at short intervals. I take these three lines to represent the frame of a feather

head-dress, such as is common in the Pacific. The line bounding the face is not complete on either side, but, judging by the small perfect maskoid on one of the sides, it came to a sharp point, but no mouth was indicated. The eyes are indicated by lines forming concentric circles, two lines on one side of the face and three on the other. The difference is apparently accidental, and depending on the area to be occupied. Below the face the lines are somewhat difficult to follow, but on the one side it appears to be plain that the upper line on each side is intended for the arms, as there is a distinct indication of an elbow. I take the two lower lines to be legs, turned up in a way not unknown in Maori carving. The edge of the curve on the inner side is closely ornamented with notches, and also the somewhat triangular space between the top of the maskoids and the shaft. The arms and legs have a triangular space beneath, which I take to represent the body of the figure. The arms and legs terminate at kite-shaped maskoids, which have double concentric circles for eyes, no mouths; but they are angled on the central line, and this angle is notched from top to bottom. The notching is continued to the point of the curved portion. The other side is practically the same.

In relation to these two figures the maskoids are upside-down, for, although there is no mouth, the part intended for the lower part of the face is easily recognised; but when we examine the ornamentation of the side we find a small full-length figure so placed that the small masks on the curved part become the heads of these figures by superposition. As will be seen from the plate, one figure represents a male drawn in a very peculiar and archaic style. On the other side is a female figure, even more peculiar in contour. The extreme end of the butt has been ornamented, but the small fragment that remains does not give sufficient indications to justify a restoration. I think, however, that there were two small figures with their heads towards the central line.

The expanded triangular area at the base of the shaft is ornamented on each side with concentric circles in addition to the notches already mentioned. The whole represents great labour, and was doubtless a sacred or highly valued possession.

The small size precludes the idea that it was part of a weapon, and I have looked in vain for any similar object in Edge Partington's Albums and other works. The only possible resemblance that I can find is to the fan-handles made of wood or whale-tooth ivory, one of which is figured at pl. xxv. and pl. xlvii., No. 6, of Edge Partington's "Album

of the Pacific" as coming from the Marquesas. Here we have the same general idea, the central shaft, the human figures at the sides, and the curved anchor-like arms, with heads at the middle of the arms, only the reverse way to those on our specimen. A replica of the head-dress with the projecting spike for a feather plume is seen on the head of a figure on a dancing-stick from New Britain (pl. ccxlv., fig. 2, Edge Partington's Album).

I may call attention to the notched characters of the ornamentation, which corresponds to the markings on the specimens figured in "Maori Art" at pl. lvi., figs. 4, 5, and 6, and which I there state to have a special character of their own. The specimen figured on pl. xlviii., fig. 5, of "Maori Art" came from the same locality as the specimen under discussion, and has a similar type of face. The small object on pl. xlviii., fig. 3, is slightly notched along the ridge, and may have represented a small mask.

It is, of course, open to any one to suggest that this specimen is not Maori, and has arrived in New Zealand through the agency of whalers or others, seeing that it is so different from any known Maori ornament or implement. Granting this for the sake of argument, the question still remains, Where did it come from? It is generally a fairly easy matter for an expert to place a specimen by its character or workmanship, but, although I have had the pleasure of showing this to several gentlemen of great experience, they do not recognise its native country or use. I trust that by publishing the photographs I may some day hear from some one that they have ascertained its origin and use. I myself think that it is possibly one of the older relics of the Maori race; and, although the use of fans is not known to the Maori of to-day, may it not have been a fan-handle used in sacred rites in the distant past, perchance in the Tihi Manono of some remote Hawaiki?

ART. VIII.—*Remarks on the Trade and Public Debt of New Zealand.*

By H. W. SEGAR, M.A., Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 18th August, 1902.*]

Plates XI.–XIV.

IN tables of the trade, revenue and expenditure, public debt, &c., for any country, it is usual to present the value in terms of some monetary unit—*e.g.*, the sovereign or pound sterling. Now, the sovereign represents a fixed amount of gold, but not a fixed exchange value. The extent to which the sovereign, or any given number of sovereigns, will purchase commodities in general varies considerably from time to time. Consequently a man with a fixed income—that is, with an income of a fixed number of pounds—may be really much better or much worse off at one time than at another because of the variations in the purchasing-power of his income. The trade of a country may be progressing well and soundly during a period for which bare statistics of values may appear to indicate a sickly and declining condition of trade, and trade may be really languishing when these statistics indicate continued progress. Before we can properly compare monetary statistics of one period with those of another we must take into account the variations in the purchasing-power of money, remembering that the value of any sum of money is the amount of commodities which it will purchase at the time.

INDEX NUMBERS.

This we are enabled to do roughly by means of index numbers. We need not enter on a general description and discussion of these in this place; let it suffice to say that their purpose is to represent the average prices of commodities at different periods, the average prices being directly proportional to the index numbers, and the purchasing-power of money consequently inversely proportional to them. The following table represents Sauerbeck's index numbers for the years 1880–1900:—

	Index No.		Index No.
1880	88	1891	72
1881	85	1892	68
1882	84	1893	68
1883	82	1894	63
1884	76	1895	62
1885	72	1896	61
1886	69	1897	62
1887	68	1898	64
1888	70	1899	68
1889	72	1900	75
1890	72		

This is illustrated graphically in Plate XI.

It will be noticed that from 1880 to 1896 prices, as measured by these numbers, steadily declined, with the exception of an interruption which culminated about 1890. The decline for the whole period, as represented by the first and last of the index numbers—viz., 88 and 61—is one of nearly 31 per cent., and this is equivalent to an increase in the purchasing-power of money in the ratio of 61 to 88, or some 44 per cent. In 1896, however, there set in a rapid rise in prices and consequent fall in the purchasing-power of money, which continued to 1900.

Index numbers are calculated by different authors in various ways and from different data with different results, and no one set of index numbers can be regarded as being exact. Indeed, they are intended to represent the average prices of commodities, the very idea of which is more or less indefinite. But, though differing somewhat in the magnitudes of the changes in prices and purchasing-power of money which they indicate, it is remarkable how concordant are the index numbers of different statisticians in indicating always the same tendency to rise or fall. These remarks should be carefully borne in mind in the following application of Sauerbeck's index numbers.

Application of Index Numbers.

We propose to take the exports, imports, and public debt of New Zealand for the years 1880–1900, and to calculate their values in terms of the pound of the year 1880—*i.e.*, to find how many pounds would have been required in the year 1880 to have the same purchasing-power as the various sums concerned in the several years. The values thus calculated we shall call the "general exchange values expressed in the pound of 1880"—(1880)£. By comparing these values we shall be able, notwithstanding the roughness of the method, to form a better idea of the course of trade and of the burden of debt than we could from the ordinary statistics, as the general exchange values thus calculated will represent the

general purchasing-power instead of merely the amount of gold equivalent at the time.

EXPORTS.

The following table indicates the application of the method to the exports of New Zealand :—

	Nominal Values.	General Exchange Values.
	£	(1880)£
1880	6,102,300	6,102,300
1881	5,762,250	5,965,623
1882	6,253,350	6,551,128
1883	6,855,244	7,356,847
1884	6,942,486	8,038,668
1885	6,591,911	8,056,780
1886	6,386,682	8,145,334
1887	6,551,081	8,477,870
1888	7,255,128	9,120,720
1889	9,042,008	10,051,304
1890	9,428,761	11,524,040
1891	9,400,094	11,489,016
1892	9,365,868	12,120,504
1893	8,557,443	11,074,360
1894	9,085,148	12,690,392
1895	8,390,153	11,908,600
1896	9,177,336	13,239,424
1897	9,596,267	13,620,552
1898	10,324,988	14,196,864
1899	11,799,740	15,270,288
1900	13,055,249	15,318,160

This table is illustrated graphically in Plate XII.

It would appear that, though the nominal value of the exports fell off after 1884 and did not recover until 1888, the general exchange value actually increased from year to year throughout this period, though not at as rapid a rate as in the few previous years. Again, after 1890 there was another falling-off in the nominal values of the exports, and the value for 1890 was not exceeded until 1897; but during these same years there was on the average a considerable rise in the general exchange values of the exports, though this rise was not steady. In two years only—1893 and 1895—were the general exchange values substantially less than in the preceding years, and in each case the succeeding year showed a greater value than any previous year. Generally the table of general exchange values represents a far more steady progress in the values of exports than does that of the nominal values, indicating that the great unsteadiness in the latter is due chiefly to the varying exchange value of gold. The

progress of our export trade, then, has not really been nearly so chequered as the ordinary statistics would generally suggest.

It will further be noticed that the increase in the general exchange values of the exports during the last few years has been less rapid than that of the nominal values, which indicates that part of the increase in our exports is only apparent; increased prices and the fall in the purchasing-power of gold would diminish the amount of commodities purchasable by the exports or the credit assigned for the same.

Imports.

The following table indicates the application of the method to the imports of New Zealand:—

	Nominal Values. £	General Exchange Values. (1880)£
1880	6,162,011	6,162,011
1881	7,457,045	7,720,240
1882	8,609,270	9,019,208
1883	7,974,038	8,557,120
1884	7,663,888	8,874,008
1885	7,479,921	9,142,144
1886	6,759,013	8,620,216
1887	6,245,515	8,082,448
1888	5,941,900	7,469,792
1889	6,308,863	7,710,824
1890	6,260,525	7,651,776
1891	6,503,849	7,949,128
1892	6,943,056	8,985,152
1893	6,911,515	8,944,320
1894	6,788,020	9,481,648
1895	6,400,129	9,084,064
1896	7,137,320	10,296,440
1897	8,055,223	11,433,224
1898	8,230,600	11,317,064
1899	8,739,633	11,310,112
1900	10,646,096	12,491,424

This table is illustrated graphically in Plate XIII.

The nominal values of the imports show a considerable depression for many years after 1882. The value for that year was not exceeded until as late as 1899, while the value for 1888 was less than that for 1882 by 31 per cent.

The general exchange values of the imports, however, show a much greater approach to regularity, though not one as marked as in the case of the exports. There is a slight depression in the general exchange values between 1882 and

1885 (the value being the greater in the latter year), but a continuous fall did not set in until 1886, and practically the recovery was complete by 1892. Since that year the increase has been considerable in both values, but proportionally greater in the nominal value than in the general exchange value. To this difference the same remark may be made as in the case of the exports.

PUBLIC DEBT.

The following table indicates the application of the method to the public debt of New Zealand :—

	Nominal Value. £	General Exchange, Value. (1880) £
1880	28,185,711	28,185,711
1881	28,479,111	29,484,224
1882	29,445,011	30,847,150
1883	31,071,582	33,345,092
1884	32,195,422	37,278,912
1885	33,880,722	41,409,771
1886	35,741,653	45,583,560
1887	36,758,437	47,569,742
1888	38,375,050	48,242,920
1889	38,667,950	47,260,829
1890	38,830,350	47,459,313
1891	38,713,068	47,315,972
1892	39,257,840	50,804,270
1893	39,826,415	51,540,060
1894	40,386,964	56,413,544
1895	43,050,780	61,104,340
1896	44,366,618	64,004,336
1897	44,963,424	63,819,052
1898	46,938,006	64,539,761
1899	47,874,452	61,955,168
1900	49,591,245	58,187,096

This table is illustrated graphically in Plate XIV.

A comparison of the two sets of values shows that until quite recently the general exchange value of the amount of the public debt, and therefore practically the burden of the debt, has been increasing far more rapidly than the nominal value. From 1880 to 1896 the debt increased in nominal value from £28,185,711 to £44,366,618, this being an increase of over 57 per cent. in sixteen years; but owing to the increased value of the sovereign, according to Sauerbeck's index numbers, the amounts of commodities in general to which these sums were equivalent were in the ratio of 28,185,711 to 64,004,336, which is equivalent to an increase of no less than 127 per cent.

Since 1896, however, a change has taken place through the depreciation of gold that then set in, though from the unbroken succession of annual additions the nominal value of the debt has necessarily been continually increasing. The general exchange value fell in 1897, and, though it rose again in 1898, it has fallen rapidly since that year. Thus, apart from the distribution of the burden of the debt over a greater population, the total burden of the debt has actually diminished since 1896 in spite of further borrowings.

Further remarks on these topics will be made in a paper on "The Flood of Gold."*

Art. IX.—*The Flood of Gold.*

By H. W. Segar, Professor of Mathematics, University College, Auckland.

[*Read before the Auckland Institute, 18th August, 1902.*]

Plate XV.

At different times different influences affecting matters of public concern become of more than usual importance. At the present time the extraordinary increase in the annual output of gold that has taken place in recent years forms a most conspicuous feature in the economic conditions of the time. It follows that a knowledge of the economic bearing of the gold-production of the world is more than usually essential to the proper understanding of economic changes.

To give some account of this is the main object of the following paper, which simply describes some well-known principles of that branch of economic science which deals with the theory of value and currency. As there is not time to reason out the theory in this, one of the more advanced departments of political economy, I shall largely depend on authorities, and shall frequently quote passages from standard writers, accepting their dictum in lieu of more extensive argument.

Variations in General Prices.

We are all aware that prices fluctuate; but it is astonishing how many have an idea that, excepting comparatively slight fluctuations due to the state of the market, the price of an article is almost on a par with its fundament properties of colour, texture, density, &c. Now, a very few references to prices at different periods should easily dispel this illusion.

* See next article.

Listen, with equanimity if you can, any housekeepers that may be present, to this price-list of provisions for the two years 1449–1450:—

		s.	d.	
Wheat	... ...	4	1	per hundredweight.
Mutton	... ...	4	6	"
Pork	... ...	5	0	"
Geese	... ...	0	4	each.
Fowls	... ...	0	1½	"
Pigeons	... ...	0	4	"
Candles	... ...	0	1	per pound.
Cheese	... ...	3 lb. for 1d.		
Butter	... ...	½d. per pound.		
Eggs	... ...	5¾d. for 120.		

This list indicates, on the average, prices less than one-twelfth of those now ruling.

When Henry VI. was held a prisoner by Edward IV. in 1470 it was only thought necessary to allow him, for the subsistence of himself and his suite of ten persons, the apparently meagre sum of £3 10s. per week. Many other such incidents must have astonished us in our early reading of history, the biblical penny in particular appearing to have a somewhat miraculous purchasing-power.

Evidently, then, the value, or purchasing-power, of money is nothing innate in the metals or coins which constitute the currency, but may vary considerably, and, as we shall see presently, sometimes rapidly. Some of these variations in modern times have been carefully estimated. Between 1570 and 1640 there was a remarkably sudden and extensive decline in the purchasing-power of money; this will be considered again later on. Coming to more recent times, the value of gold, according to the estimate of Professor Jevons, fell 46 per cent. between the years 1789 and 1809; and from 1809 to 1849 it rose again no less than 145 per cent., while between 1849 and 1874 it fell again at least 20 per cent.

Prices, then, may not only fluctuate from day to day, week to week, and year to year through changes in the conditions of business, fluctuations with which we are all familiar, but may in the course of years reach altogether different levels. And this is true not only of the prices of any one commodity, but of the prices of commodities in general, or the average level of prices. For instance, it may be noticed that in the list of provisions given above the relative differences in prices of the various articles as compared with those of the present day are very small compared with the differences in the prices of any one article then and now. It would appear, then, that the extraordinarily small prices in the list were due not to a

great supply of and small demand for these articles, but to some other and more general cause, which must be capable of explaining how commodities in general should at one time have prices so greatly different from those at another.

Influence of Money-supply on Prices.

Now, it is quite certain that, other things being the same, a change in the quantity of money in circulation affects prices. "That commodities would rise or fall in price in proportion to the increase or diminution of money I assume as a fact which is incontrovertible," wrote Ricardo, supposing implicitly, of course, that other conditions remained the same. Mill, his disciple, followed in similar strain: "The value of money, other things being the same, varies inversely as its quantity, every increase of quantity lowering the value, and every diminution raising it in a ratio exactly equivalent." And, again, "Let us suppose that to every pound, or shilling, or penny in the possession of any one another pound, shilling, or penny were suddenly added. There would be an increased money demand, and, consequently, an increased money value or price for things of all sorts. This increased value would do no good to any one—would make no difference, except that of having to reckon pounds, shillings, and pence in higher numbers. It would be an increase of values only as estimated in money, a thing only wanted to buy other things with, and, would not enable any one to buy more of them than before. Prices would have risen in a certain ratio, and the value of money would have fallen in the same ratio. It is to be remarked that this ratio would be precisely that in which the quantity of money had been increased. If the whole money in circulation was doubled prices would be doubled; if it was only increased one-fourth prices would rise one-fourth—there would be one-fourth more money, all of which would be used to purchase goods of some description. When there had been time for the increased supply of money to reach all markets, or (according to the conventional metaphor) to permeate all the channels of circulation, all prices would have risen one-fourth. But the general rise of price is independent of this diffusing and equalising process. Even if some prices were raised more and others less the average rise would be one-fourth. This is a necessary of the fact that a fourth more money would have been given for only the same quantity of goods. *General* prices, therefore, would in any case be a fourth higher." And, once again, "That an increase of the quantity of money raises prices and a diminution lowers them is the most elementary proposition in the theory of currency, and without it we should have no key to any of the others."

Sidgwick also writes, "An increased supply of gold not accompanied by a corresponding increase in the work that coin has to do (or a rise in the demand for gold otherwise caused) tends ultimately to lower the purchasing-power of money relatively to commodities generally."

But the change in the purchasing-power of money is only inversely proportional to the quantity *when other things remain the same.* If other things do not remain the same, the actual change in the purchasing-power may exceed or fall short of this amount; the increase in the quantity of money would still *tend* to produce the depreciation in the purchasing-power stated in the quantity theory as enunciated in the above extracts, but the actual effect would be modified by the coincident effects of the other influences.

To be able to form some idea of the probable course of prices it is necessary to consider what these influences are, and what is the nature of their action.

OTHER FACTORS INFLUENCING PRICES.

What, then, are the other factors which affect general prices? They are mainly—(1) The amount of exchange transactions to be performed—*i.e.*, the quantity of commodities to be exchanged; (2) the proportion of credit to cash transactions; and (3) the rapidity of circulation of money. Prices depend on all these three factors combined with the quantity of money in use, and each of these has its effect independently of the others, and the actual change in prices is the resultant of the effects of the whole four.

Let us consider, however, the probable magnitudes of these effects. How rapidly does the amount of exchange transactions to be performed increase? It tends to increase with the population and the development of commerce and general business. This leads to a demand for additional coin which is at times substantial, but which at any time is difficult to estimate with any proper degree of accuracy. For our purposes, however, this is hardly necessary. Let it suffice to notice that if the other influences were constant the steady increase of population and general commercial development would lead to a continual fall in prices, through the spreading of the money in use over a greater number of transactions.

Coming now to the proportion of credit to cash transactions, it must be noticed that this is comparatively a very variable quantity. In good times, when business is brisk, we observe generally a rise in prices. This is because the expansion in credit which accompanies commercial prosperity more than counteracts the direct tendency of the increase of business to diminish prices. In bad times these influences are reversed. There is a shrinkage in credit which produces

low prices. These changes take place in comparatively short intervals. The change may be sudden and of the nature of a panic, or may extend and operate gradually over a period of, say, five or six years. But, in addition to these short-period fluctuations, we have a general tendency as the commercial status of nations improves for the proportion of credit to cash transactions to increase. In those nations which are commercially most advanced we find to-day the proportion greatest, so that in some of the wealthiest nations we find a smaller amount of coin per head in use than in some of the poorer nations. We may take it that the general tendency is to economize the use of money and substitute credit, and this, so far as it operates, tends to increase prices.

The rapidity of circulation of money—*i.e.*, the average frequency with which each coin is used to pay for some purchase—must depend largely on the character and customs of the people. But the modern tendency is to keep coin in hand to as small an extent and for as little a time as possible. This, again, tends to increase prices, since it practically diminishes the demand for money.

Thus of these three influences we have seen that one is tending to diminish prices and the other two to increase them. Thus to some extent they counteract one another; and, besides, apart from short-period fluctuations, the extent of their influence varies comparatively slowly, and may be almost neglected, compared with that of any great increase in the gold-supply.

Some Instances of Variation in the Purchasing-power of Money, and their Causes.

It will now be well, perhaps, to consider some instances of variations in the purchasing-power of money that have actually occurred, and their causes. Beginning with the fall of the Roman Empire, we may remark that during that event the production of the precious metals received a shock from which the industry did not recover for a thousand years. Even when a revival came, in the eighth century, the production was only sufficient to replace waste and to keep the volume in circulation about the same up to the time of the discovery of America. During all this period the precious metals were steadily advancing in value and average prices were falling, at first through the reduction of the stock by wear-and-tear, but also at a later period through reviving trade and production making a larger and larger demand for money. It was to the later portion of this period that the list of prices of produce quoted above applied, and this sufficiently exhibits the lowness of prices at that time.

America was discovered in 1492, but it was not until the invasion of Mexico by Cortes in 1519 that the yield of precious metals in America became greatly increased. Humboldt estimates the annual production from 1521 to 1545 at £630,000, and Mr. Jacob estimated that for the following fifty-four years, 1546–99, at an average of £2,100,000, whilst simultaneously the production of the mines of Europe was greatly increased. Economic effects were not transmitted as rapidly from country to country in those days as now, and it was not until the latter portion of the sixteenth and the earlier portion of the seventeenth centuries that the effects of the greatly increased supply of the metals appear to have been realised in the prices of commodities in Europe. But when the effects were once noticeable they became very marked—*e.g.*, corn rose from about 2 oz. of silver the quarter to 6 oz. or 8 oz., and generally money in Europe sank to about one-fifth of its former value, prices rising to about five times their former level.

Take, again, the recent period, 1850–70. Through the discovery of the Californian and Australian goldfields the supply of gold throughout this period was largely in excess of all known previous epochs, and was largest in the decade 1851–60. A study of the general prices of commodities by means of index numbers establishes for the period 1850–70 a considerable rise. Comparing the depressed year 1850 with the depressed year 1869 we get, by means of Mr. Sauerbeck's figures, a rise in prices of about 27 per cent., whilst other estimates (those of Dr. Giffen, Professor Soetbeer, Mr. Palgrave, and the *Economist*) give very similar results, though the exact proportion is differently estimated, and this in a period when improvements in methods of production and transport and the exploitation of new countries might have been expected to cause a general fall in prices. Further, a general rise in money wages between 1850 and 1870 has been clearly established. Thus, the fact of a fall in the standard of value between 1850 and 1870 seems proved, and 20 per cent. is the most moderate estimate that is accepted.

Between 1870 and 1893, on the other hand, although the production of gold was still very great, it was less than in the previous twenty years. Great new demands on the stock of gold for currency were made by Germany, the United States, Italy, and Austria-Hungary. The consumption of gold for the arts increased, and has been very roughly estimated by Professor Soetbeer at £11,500,000 sterling, nearly one-half of the total annual production. The hoards of gold for war treasure by the great Continental nations grew. The demand for gold in India (a new demand, specially important in the decade 1860–70) con-

tinued, and absorbed in the years 1870–93 nearly £70,000,000. The bulk of trade over the whole world increased steadily, and a larger proportion of it was conducted on a gold basis. Consequently the general prices of commodities, which had previously risen, showed during this period a considerable net fall, bringing them lower than they had been in 1850. The general level of wages was probably lower in 1893 than in 1870, though the fact of the fall, and especially its amount, is not as certain as the fall in commodities.

We come now to the consideration of the prices of the last decade and the probable course of prices in the near future; but it is advisable first to consider the recent supply of gold and the probable supplies of the next few years.

The Gold-supply of Recent Years.

Now, the gold-supply from 1841 to 1900 is given in the following table, with that of some earlier periods also stated for the sake of comparison:—

	Annual Average in Millions. £		Annual Average in Millions. £
1493–1520	0·74	1888	20·50
1601–20	1·06	1889	22·23
1701–20	1·60	1890	24·26
1801–10	2·20	1891	23·47
1841–50	6·83	1892	29·90
1851–55	24·64	1893	32·60
1856–60	25·71	1894	36·77
1861–65	23·10	1895	41·00
1866–70	23·95	1896	45·00
1871–75	21·29	1897	51·71
1876–80	21·51	1898	59·86
1881–85	19·33	1899	64·65
1886	19·56	1900	53·11
1887	19·18		

The part of this table applying to the period 1850–1900 is illustrated graphically in Plate XV.

It will be noticed that for the thirty years from 1861 to 1890 the annual output of gold did not vary greatly in either direction from £20,000,000. After the latter date it rose, however, with leaps and bounds, until in the year 1899 it reached 64·65 millions. The increase was continuous as well as rapid. The output for 1898 was £11,000,000 greater than that for the previous year, while in the following year—1899—the output was again greater by £5,000,000, although this was the year in which the war in the Transvaal began, and mining in that country was brought practically to a standstill. When it is remembered that the Transvaal was putting out gold at the rate of £20,000,000 a year when the war began to disturb mining operations, it will be understood that but

for the war the increase of the world's stock of gold for 1899 would have exceeded that for 1898 by a still greater amount.

For 1900 the output of gold fell to 53·11 millions, or there was a falling-off of £11,500,000 compared with the previous year. But for this year the contribution of the Transvaal sank to the comparatively insignificant sum of a quarter of a million, so that if the Transvaal had been putting out gold even only at the same rate as at just before the war there would again have been an increase on the previous year measured by many millions. In 1901 again there was an increase of several millions on 1900, although the contribution of the Transvaal was even more insignificant than before.

THE GOLD-SUPPLY OF THE FUTURE.

Thus as soon as gold-mining in the Transvaal has been generally resumed we may expect the annual output to be some £80,000,000. But the annual yield may be expected to increase more and more. It must be remembered that gold is now chiefly obtained by quartz-mining. The placer claim is no longer the chief source of the gold-supply, and consequently the supply is no longer subject to the vicissitudes invariably connected with alluvial-gold mining. Gold-mining is now more akin to general mining; great capital is sunk in working great reefs, and many of the most profitable mines have every prospect of keeping up their supply for generations. Thus extensions in gold-mining are generally of far more permanent character than formerly, while these extensions are evidently being made on a large scale. The great annual increases sufficiently prove this; and the fact that when allowance is made for the temporary collapse in the supply from the Transvaal these increases still remain enormous, makes it appear that general extension in gold-mining is still the order of the day. New fields are continually coming to the fore. In West Africa an extensive field has been discovered exactly corresponding in formation to that of the Transvaal, and numerous companies have been formed to exploit it, though it is too early to foretell with what success. The goldfield of the north-west territories of Canada is 500 miles long by 100 miles in its greatest width. Rhodesia furnishes one of the youngest fields, but the rapid increase of the output seems to promise great things, the output in the years 1899, 1900, 1901 being respectively 65,000 oz., 91,000 oz., and 140,000 oz., although in the two latter years operations were greatly impeded by the war and a consequent scarcity of labour. The output of gold from India increased fourfold during the period 1890 to 1901.

And so on all over the world new fields are being discovered, and old fields are booming again through the im-

provements in and cheapening of the process of gold-extraction. Thus we have every reason to anticipate a still further greatly increased yield, and that the increase will be more permanent than it was in the middle of the last century because of the difference in the character of the mining.

Increased Prices to be expected.

But, taking the annual output of the immediate future at £80,000,000, what effect ought this to have on prices? Let us consider what can become of this £80,000,000 a year. It will partly be (1) used in industry and the arts; and (2) hoarded. The rest must be used as money, either as coin or bullion.

Now, the amount of gold used in industry and the arts can scarcely be estimated with accuracy; but very careful estimates have been made, and Dr. Soetbeer estimated 11·20 millions for the year 1885. Since the amount of gold used in this way is not likely to increase with great rapidity, we may take £15,000,000 as being a fairly liberal estimate for the present time.

Let us also deal liberally with hoarding, and allow another £5,000,000 for this source of consumption; we should then still have £60,000,000 per annum to be added to the currency of the world. This is at least 4 per cent. of the stock of gold in the world, and would of itself tend to increase average prices at the rate of about 4 per cent. per annum.

Now, a comparison with what happened in the last century may be made. The output then rose to as much as £28,000,000 a year, while £3,500,000 only was used annually in industry and arts; so that, allowing liberally again for hoarding, at least £20,000,000 per annum must have gone for a time to the increase of the currency, and this represents about 5 per cent. on the amount of coin then in existence. But we know that the increase in prices that took place was not proportional to this, amounting perhaps only to about 20 per cent. altogether before prices began to fall again. Jevons, after a very careful investigation, foretold a rise in prices of about double this, while others ventured to predict that prices might ultimately rise to as much as threefold; but all these estimates were falsified. Evidently, then, there must be some great difference in the circumstances then and now if we are to venture on any similar prediction. I am of opinion these necessary differences do exist.

To begin with, the annual gold output did not continue to increase, or even to maintain itself, as was expected. This was due to the nature of the fields and the mining, and we have already seen that now much greater permanence is to be expected.

Again, average prices depend not only on the supply of gold, but also, amongst other things, on the demand for gold. Now, simultaneously with the increased output of gold of fifty years ago there took place a great extension of railways and improvement in transit facilities, with a rapid development of new countries, that caused generally an extraordinary expansion of industry—*e.g.*, the exports of England increased from £60,000,000 in 1848 to £165,000,000 in 1860; and the increased trade and prosperity required an increased coinage even to keep prices at the same level. No correspondingly great development of trade, &c., can be expected in the near future.

Further, the existence of an effective bimetallic area of considerable extent tends to minimise the effects of an increase in the total gold currency. For, if gold tends to depreciate, the bimetallic countries will import and coin gold to replace the silver, which they will export. And so we find France in 1850–65 taking gold and exporting silver, and during the years 1853–60 actually coining £155,000,000 sterling in gold, or some six years' product of the mines. But at the present time, in all the principal countries and commercial centres of the civilised world, gold is the sole standard of value. The demand for gold and silver is no longer alternative as currency.

As an international measure of value gold has been becoming more and more isolated, while silver is now more of a mere commodity; any increase of supply of gold, or any diminution of supply, acts with full force upon the standard of value. There is no longer a question of the proportion of any new demand or supply to the total stock of gold and silver, but of its proportion to the total stock of gold alone.

I see, then, no reasonable escape from the conclusion that in the near future prices must rise, and rise considerably. Prices have already risen.

Mr. Sauerbeck's index numbers representing the average prices of forty-five commodities, compared with the prices of the same articles in 1867–77, are as follows:—

1867–77 = 100.

	No.		No.
1879 ..	83	1890	72
1880 ..	88	1891	72
1881 ..	85	1892	68
1882 ..	84	1893	68
1883 ..	82	1894	63
1884 ..	76	1895	62
1885 ..	72	1896	61
1886 ..	69	1897	62
1887 ..	68	1898	64
1888 ..	70	1899	68
1889 ..	72	1900	75

This table is illustrated graphically in Plate XI. of Art. VIII. It gives an increase in prices from 1896 to 1900 in the ratio of 61 to 75, or an increase of nearly 23 per cent.

Index numbers are compiled by different investigators in different ways and from different data, but they agree to a very considerable extent. The most numerous set of observations is that which Dr. Falkner has compiled in the inquiry on wholesale prices from 1890 to 1899, recently published in the "Bulletin of the Department of Labour," U.S.A. In these observations the index number for all articles shows a decline from about 102 in 1890 to about 81·5 in 1897, but then, again, a rise to about 92 in the first two months of 1899.

A similar conclusion is reached by Dr. Conrad, who combines Soetbeer's observations of Hamburg prices, and various other independent indications concur in placing the turn of the tide in prices beyond doubt. This increase of prices has been generally recognised, but in the Press and by popular opinion the war seems to have been the favourite attributed cause, and almost all conceivable hypotheses but the true one have been brought forward; and this cause is likely to be of comparative permanence and have an increasing force.

It is true that a fall in prices again set in towards the end of 1900, but a rise in prices due even to a permanent increase in the gold-supply can scarcely be expected to be continuous. One year may see an enormous output of gold, and the next year may see prices smaller than those previously ruling. A collapse in credit may temporarily counteract or more than counteract the influence of the expanding currency. And this may happen frequently, and perhaps the more frequently because the general tendency of prices to rise gives an impulse to business and encourages speculation. But the low prices when credit is small and the higher prices when credit is good will fluctuate about a mean which is continually rising, just as in the case of the ocean the depth at a given point may vary according to whether we have there the crest of a wave or the bottom of the trough between the waves, although the tide may be rising at the time and the average depth continually increasing. And two observers on the sea-beach may form very different estimates of how far the tide has risen while watching the ebb and flow of the breakers, though they may agree, and there may be no doubt, that the tide has risen.

An instance of this irregularity in the rise of prices is thus described by Professor Marshall: "An expansion of credit coincided with the influx of precious metals consequent on the discovery of the Californian and Australian mines, and increased the upward tendency of prices. But in 1857 there

was a crisis—*i.e.*, many trading firms were unable to pay their debts, credit was violently contracted, and prices fell, although the store of precious metals in the country was growing as rapidly as ever. After a time credit began to expand again, and prices rose till 1866, when there was another crisis, and prices fell. Again credit expanded, and prices rose till 1873, when, though there was no crisis, a gradual contraction of credit set in which has continued till 1879." But "the lowest point which prices reached between 1857 and 1866 was much higher than the level of 1850; and the lowest point between 1866 and 1873 was higher still."

And just as it matters little that the rise in prices has not been continuous, so it will not do to object that all prices have not risen—that, *e.g.*, wool was lower in price recently than for many years past. If prices on the average remained the same, we should still have some rising and some falling according to the circumstances of the demand and supply of each particular article. And when prices on the average are rising or falling through an increase or diminution in the currency, the price of any particular article will also be affected by these same circumstances, which may aid or hinder the influence of the currency, and may completely counteract it in the case of some particular commodity or commodities. On this point Professor Flux writes, "A frequent objection made to the statement of the dependence of the average level of prices on the quantity of money in circulation is that the variations of different prices are by no means of equal amount, and that some prices have not fallen at all during the last quarter of a century when on the average wholesale prices have fallen 35 to 40 per cent. As well allege that the rise and fall of the tide on our coasts is not due to the tidal waves which are produced by the attractions of the moon and of the sun. Neighbouring places have tides of vastly different heights, but all would vanish were their original cause destroyed. We have spring tides and neap tides according to the relative position of the crests of the lunar and solar tidal waves, and clearly due to these influences, though in some places the variation is less, in others enormously more, than in the centre of the ocean. The formation of coast-lines and the location of land-masses modify infinitely the observable results of one common cause, while the wind may, again, interfere to reduce or increase the actual movement at a given place. So also with prices: they show indefinite variety of variation, due to the common influence—changes in the amount of the monetary circulation—but that they do respond to that influence can be as well denied as that the tide at London Bridge is a result of the same funda-

mental tide-producing causes as those which affect the tides at Teneriffe."

The rise in prices cannot, of course, go on indefinitely. Actual gold-mining must pay if it is to be continued; but if prices continue to rise, then, except for the influence of discoveries and improvements in working, the exploiting of ore of a given grade must become more and more costly, while the yield for work done remains the same. Thus the mines containing ore of very low grade must be abandoned, then others with ore of a still better grade, and so on. Thus the poorer fields are likely shortly to suffer. In the case of the Auckland goldfields expenses have been kept down by the failure of the recent appeal of the miners to the Arbitration Court, but with prices rising and wages rising in every other trade the wages of the miner must sooner or later partake of the general advance. This must mean a severe check to the gold industry of the province.

Effects of Depreciation of Gold.

The economic effects upon trade, industry, and society of a rapid depreciation in the value of gold are of the highest importance, but so numerous that we cannot attempt to consider them all; nor can we spend much time in the consideration of any one. Many of my remarks must be somewhat of mere suggestions.

Many classes of individuals must suffer. Those that suffer most are those with incomes derived from investments in funds, annuities, mortgages, &c. These include men retired from business and those who by age, sex, or infirmity are dependent on provision which has been made by others. The value of such provision is diminished, and in the case of insurance the money assured is, when received, of much less value than the same sum would have been at the time when most of the premiums were paid. Such as earn incomes made of fixed charges established by law or custom, as in the case of lawyers and physicians, likewise suffer; but they obtain some compensation, for, the fees remaining nominally the same, there is virtually a reduction of charge and a consequent increase of business. Companies and individuals contracting to perform fixed services at fixed prices also belong to this class, perhaps the greatest instance being that of tramway companies, which exist all over the world, and are bound by the municipalities to charge no more than certain maximum fares. These companies must find their expenses continually increasing. Increased traffic, due to increase of population and the virtual reduction of fare, may compensate for this more or less, but the success of such ventures must in general be smaller than if gold did not depreciate. The earners of

salaries, as the civil servant or professional man engaged at fixed salary, form another class to whom the depreciation of gold is injurious. For such salaries are slow to move, and as the cost of living increases the salary will purchase less and less. The loss which fell long since on the civil servants of India through the depreciation of silver seems now about to involve their brethren throughout the world. The earners of wages also may suffer a little; but at the present time, and in this colony, when the increase of wages does not actually precede the increase in the cost of living it very soon follows, so that there need be no anxiety for the position of the labourer and artisan as directly affected by the depreciation of gold. Arbitration Courts are not indispensable to insure wages keeping pace with prices, as witness the general rise in wages that has taken place of recent years beyond New Zealand as well as within it. The creditor, as such, also loses; as each year passes by the interest he receives is of less value to him than before, and when ultimately his principal is returned to him, though nominally of the same amount as when lent, it is of less use to him than it would then have been in the purchase of commodities.

So greatly did these influences operate after the discovery of America that Professor Walker describes the consequences of the metallic inflation that followed in the following words: "So rapid was the fall, so great the disturbance of trade and industry that followed, so wholesale the reduction in the value of fixed incomes and permanent charges, that widespread distress and much permanent pauperism resulted. . . . Mr. Jacob attributes to the overwhelming changes in the purchasing-power of money at this period that sudden increase of pauperism which gave occasion for the establishment of the English poor-laws, and those financial embarrassments of Charles I. which led to the great rebellion. Instead of a slow and gradual diminution of the weight of indebtedness (that mortgage which the representatives of past production hold upon the produce of present labour), debts were in many cases almost confiscated by the rapid depreciation of the money in which they were to be paid. The creditor class was very generally impoverished, if not hopelessly ruined." And, again, "Of those who had possessed barely enough for the support of old age or helpless infancy, great numbers were impoverished and brought into dire distress. The traces of the deep disturbances of that time long remained upon the face of English society. But it was not alone upon the upper classes that misfortune fell. Serving-men and domestics were discharged by reduced gentlemen faster than the existing industries or new enterprises

could take them up. Moreover, the wages of labour never, as we have seen, rise as soon as prices of commodities. In an advance of prices as rapid and furious as that we are speaking of wages fell far behind, and the labouring-classes found themselves continually poorer, in spite of the large amount of silver which was paid them weekly. Those heaviest loaded in the race—the men of large families, and such as had the misfortune to be sick or temporarily disabled—were compelled to resort to charity. . . . Such was the condition of things under which vagabondage and mendicancy rose to gigantic proportions, and in which originated the pauper system of England. Mr. Jacob and Professor Cairnes are agreed in attributing the poor-law of Elizabeth to the wholesale destruction of accumulated fortunes and the rapid overmastering changes of productive enterprise which followed the flood of new metal from the Spanish-American mines."

Returning to the remark that creditors, as such, lose, this suggests that when gold is depreciating it is a bad investment to lend out money at interest, since a real loss in principal should be made good, and this would require an increased interest. If lenders knew when this influence was at work and generally acted on it interest would rise; the virtual loss of capital would thus be made good by the addition of a suitable sinking fund, and the lending of money would continue to compare favourably with other investments. But, as Walker remarks, the operations involved in mental discount are amongst the most difficult which ordinary men are called upon to perform, and in these most persons fail entirely; consequently we find that when gold is depreciating interest falls, owing to the greater fund which the increase of money provides for new enterprises and the extension of existing branches of production. This influence has its full effect, whilst the other, which should more than counteract it, is almost inoperative. Consequently it would appear that money had better be invested in real estate, or some equivalent form, which, while returning a fair annual remuneration, would also increase in money value in proportion at least to the general increase of prices. This, of course, would only be a general rule; in any particular locality the removal of the sources of prosperity may take away a great portion of the value in the real estate of the neighbourhood.

But as the creditor loses the debtor gains. The annual charge becomes virtually smaller and smaller, as does the principal to be paid.

Now, the producing class are generally debtors, and as such feel the relief that this affords. But the producer is also

benefited in other ways. The cheaper money and greater credit which usually accompany an inflation of the currency enable him to obtain a greater profit, and perhaps to extend his business; and the profit is still further swollen in the case of the manufacturer of those commodities which are chiefly in demand by the fact that he gets prices for his products increased in a greater ratio than the wages he has to pay. This encourages enterprise and gives a fillip to general trade and industry. Thus, as David Hume wrote, "In every kingdom into which money begins to flow in greater abundance than formerly everything takes on a new face; labour and industry gain life, the merchant becomes more enterprising, the manufacturer more diligent and skilful, and even the farmer follows his plough with greater alacrity and attention." It is true goods have to be exported to pay for the imported gold, or part of the national supply of labour has to be diverted to gold-mining; but this economic loss is more than made good by the encouragement given by the rising prices to general industry.

According to Professor Walker the increase of the money-supply after the discovery of America, in spite of the distress produced mainly by the extraordinary rapidity of the increase, contributed greatly to the rise and growth of the maritime power of Great Britain; and, in the language of an economist so careful as Professor Cairnes, it supplied and rendered possible the remarkable expansion of oriental trade which forms the most striking commercial fact of the age that followed. "Among the more strictly political results of this great movement can be traced, in clear lines, the hastening decay of the feudal power, the increasing dependence of the sovereign upon his people for the supplies which his hereditary domains no longer furnished in sufficiency, and the rising spirit of self-assertion on the part of the commercial and mechanical classes."

At the present time the increase of money might conceivably be so rapid as to bewilder the trader and producer and exalt the ordinary courage and enterprise of business to rashness, and in such a case the effects would be mostly prejudicial; but it is scarcely likely that we are on the eve of such a momentous discovery as would be required to effect this. It is more likely, though it is scarcely safe to prophesy, that the increase in prices, while necessarily injuring certain classes, will proceed at such a pace as will produce the better effects which a depreciation in the currency can cause, and promote the prosperity of the community as a whole.

It remains only to consider how the depreciation of gold will affect the Government, and the citizen in his relation to the same. Will the taxation of the average citizen increase? As most of our taxes are of the nature of *ad valorem*, and are determined by our expenditure, the majority of taxes will not

increase in proportion to expenditure. Of course, those who obtain large money incomes as a consequence of the depreciation of gold, and indulge in a correspondingly large expenditure, will pay taxes in proportion. The income and land taxes are, however, exceptional because of the exemptions; these exemptions will become virtually smaller and smaller, and more incomes and smaller holdings of land will become subject to direct taxation.

In the case of the revenue, Customs duties will increase with prices; land-tax and income-tax should increase rapidly; while railways, postal, and telegraph receipts, though made up of fixed nominal charges and so liable to virtual loss, may possibly show expansion due to the depreciation of gold and the consequent virtual reduction in the charges. On the whole, and on the average, expanding revenues are to be expected, though there may be at any time a temporary relapse, as there may be a check to the upward tendency of prices.

Expenditure, on the other hand, will not tend to increase nearly so rapidly, for the expenditure of the Government is to a very large degree made up of fixed charges, and salaries, which, though not fixed, respond but slowly to the general upward tendency. An era of big surpluses has already set in, and for the above reasons may be expected to continue, except in so far as temporary depression may interrupt them.

One item in the Government expenditure deserves further remark—that of interest and sinking fund. This amounted in 1901 to £1,745,616 out of a total expenditure of £6,514,049, or more than one-fourth of the total. However gold may depreciate, this charge will nominally be unaffected by such depreciation—*i.e.*, there will be a virtual reduction in the charges. If the value of gold, *e.g.*, were to depreciate by one-half, the burden of the present debt and the debt itself would be virtually reduced to one-half, and generally the virtual reduction in the present debt and in the charges it necessitates will be in proportion to the reduction in the value of gold. For nearly a generation the colonies, as debtor nations, have been hampered and their progress retarded by the appreciation of gold and the consequent virtual increase of debts. A change has set in and must continue for no little time; the colonies will feel the burden of old debts less and less, and this is already, and will be to a greater extent in the future, one of the most powerful influences towards prosperity. Creditor nations, on the other hand, must suffer; the interest they receive will represent a smaller and smaller portion of the world's goods.

Most that has been said with respect to the Government will also obviously apply to municipalities and other local bodies.

In conclusion, it may be remarked that the beginning of a period of depreciation in the currency is pre-eminently a time favourable to borrowing. I would not suggest borrowing for any and all purposes; what is not wanted may be dear at any price. But if there are certain improvements that are recognised as necessary to be effected in the near future the sooner they are effected the better; it may be advisable to wait a little to tide over a temporary scarcity in the money-market and a temporarily unfavourable condition of the labour-market, but the first favourable opportunity should be seized—the burden incurred will grow lighter and lighter. In fact, just as an era of depreciating currency promotes enterprise and business in the case of the individual, so it should generate in Governments, central and local, an increased eagerness to initiate schemes for the welfare of their people.

ART. X.—*Nature's Efforts at Sanitation.*

By R. H. MAKGILL, M.D., D.P.H.

[*Read before the Auckland Institute, 20th October, 1902.*]

FOR those whose duty it is to frame laws and construct works for the safety of the public health nothing can be more profitable than the study of the methods adopted by Nature. What could be more perfect than the way she deals with what we are accustomed to regard as waste matter? Her system, as I shall attempt to explain, is at once effectual and economical, since everything is utilised as well as rendered innocuous. Nature has framed certain sanitary laws more reaching than any by-laws the most exemplary local body ever conceived, for we cannot evade their working, however we may attempt to ignore them.

ELIMINATING THE UNFIT.

If a community elects to live in narrow dismal streets where the air cannot circulate, and allows the sun to be excluded by smoke and high walls, and fails to give Nature's scavengers opportunity to dispose of the waste material, the penalty will assuredly follow. Natural law says such people must be kept in check, consequently their children grow up pale, weakly, and abnormal, an easy prey to Nature's most drastic remedy, epidemics of infectious disease. Overcrowding is dealt with by the law of the survival only of the fittest; the weakly ones increase only to be weeded out that the balance may be restored. Where the most primitive condi-

tions of filth and overpopulation prevail—as in Chinese cities—the penalty takes the form of such epidemics as typhus, plague, and cholera. In more civilised communities, where at least the grosser part of the filth is removed, there is still the punishment to meet the crime in the shape of tuberculosis and pneumonia. Even where science does its best to counteract the law, and we have the best artificial sanitary efforts—good drainage, well-ventilated houses, and inoculation against disease—the law still asserts itself, and unnatural methods of life lead to nervous disorders, digestive troubles, and so forth.

It has often been said that the London "cockney" does not survive beyond the third generation, and doubtless there is some truth in this. The best text-book in which to study the working of these laws is the Registrar-General's annual report. Compare the death-rate for town and country and we find a progressive rise as the population grows denser. In 1895 the returns for Great Britain showed a death-rate of 12·7 per thousand of population, where there were 138 persons to the square mile; but it rose to 33 per thousand where the density was 19,000 per square mile. New Zealand had, in 1901, but 7·4 persons per square mile, yet the death-rate was 9·8 per thousand—not so much behind the English rural death-rate, and with only one-twentieth of the density. Here is evidence of the working of the law against overcrowding in spite of all our efforts. Why in a new country like this, with the lessons learnt in older communities to benefit by, and with ample room at our disposal, our legislators should have seen fit to take the standard of overcrowded London and fix a scanty 150 square feet as the minimum space to be allowed per dwelling it is hard to say. Surely we could avoid the evils of overcrowding at this early stage in our history.

Dr. G. V. Poore, a most eminent sanitarian, in dealing with overcrowding, remarks, "We have long been accustomed to hear that our chief sanitary necessity is pure water. This would be quite true if we were fish. But it is obvious that the air we breathe is of greater importance than the water we drink, seeing we take a draught of air about twenty times a minute, while many of us do not take a draught of raw water from week's end to week's end." Sunlight and fresh air are our greatest sanitary assets, and we should not despise them.

The consideration of Nature's methods leads us to such endless fields for study that I do not propose to-night to do more than discuss two important branches of the subject: First, the disposal of organic waste in Nature; secondly, the laws by which our bodies are protected against the inroads of infectious organisms.

ORGANIC WASTE.

There is a well-known saying that there is no waste in nature, and the truth of this is most strikingly observable in the constant circulation of organic matter. The relationship between animal and vegetable life is a simple illustration, the animal building up its body by means of the grass it eats, which building process is accompanied by a breaking-down or combustion, shown by the exhalations of carbonic acid and water in the breath, waste products of the vital process. The green leaves of plants absorb the carbonic acid, using the carbon and giving off the oxygen to aid in the further combustion, while the water is deposited as dew, to be absorbed by the rootlets. The plant utilises the waste products of animal life, and, building them up, furnishes a fresh supply of food.

The most interesting point is the circulation of nitrogen—the most important element in organic matter—for by following this up we learn about Nature's scavenging process, by which organic waste material is not only disposed of but re-utilised. Organic matter is a complex body, built up by vital processes of the elements, carbon, oxygen, hydrogen, nitrogen, and sulphur. These elements are too valuable to waste, and therefore when a plant or animal is dead the mass of organic matter becomes a potentiality for further life. But Nature does not seize on the dead body and hustle it down a sewer, to be deposited on the sea-beach, nor does she bury it in a hole so deep that it is not available for any purpose. Instead, the body lies on the surface of the ground, and an army of sanitary officials at once set to work to make use of the stored material. And things are so balanced that each, while unconsciously working out the general scheme for disposal and utilisation, is at the same time making his own livelihood in the process. The first of the scavenging party to appear is familiar and objectionable—the blow-fly and house-fly. They come to feed and lay their eggs, so that the young, when hatched, will be assured of a plentiful supply of food. It may be objected that the fly is a weak point in Nature's scheme, as it is certain it can carry infection from diseased matter. But in that scheme it is not intended that decaying matter be smeared round our dwellings, so giving the fly a chance to spread disease. Our sense of smell may be regarded as a sanitary precaution, warning us to avoid the close proximity of offensive things, just as it doubtless serves to guide the fly to his special form of food. As decomposition advances another set of scavengers appear—namely, varieties of beetles, who live on the fatty matters. The well-known burying beetle is a specially energetic member of this

group of workers. Later another variety of fly appears, which also feeds on the fatty matters; these are the small flies which we find in cheese. The next contingent are very minute insects—the mites—whose work tends to dry up and mummify the now highly decomposed body. This prepares it for a further set of mechanics, whose food is found in the dried skin and ligaments; these are certain moths and beetles. Finally a variety of beetle sets to work to utilise all the *débris* left by the other squad of scavengers, working it into the soil and tidying it all up. These insects appear in regular routine, and do the grosser part of the clearing process.

The Microbe.

But the principal force making for the reduction of the complex mass of material is the microbe. The process of putrefaction by which organic matter—animal or vegetable—is broken down and dissolved is produced by bacterial life. And we are entirely dependent on the bacteria for the conditions necessary for existence, for if they were absent organic matter would not decay, plants could not live, and food-supply would cease. These micro-organisms require for their life, moisture, certain salts, and nitrogen and carbon in some form, varying with the variety of the bacteria. One group derive their nitrogen and carbon from the breaking-down of already organized material, and others do so from the simplest elements, building them up into the complex materials of which their own bodies are composed. Thus it would not be supposed that distilled water contained the elements of life even for bacteria. Yet one variety will grow in it, deriving its nitrogen and carbon from impurities in the air, such as carbonic acid and ammonia. But it is the first or breaking-down group which causes decomposition. An important feature of this process is that the bacteria which cause disease and death do not themselves long survive the decay which then sets in. The putrefactive organisms are antagonistic to them, and in course of time they disappear. Doubtless some survive in a modified form when conditions are favourable, and lie dormant awaiting an opportunity to again assert themselves; but thorough exposure to air and light, combined with the antagonism of the putrefactive organisms, and those universally present in earth and water, serve to kill out most disease-producing germs.

Inquiring now as to the agency by which these bacteria produce their solvent effect, we find that the growth of bacteria is accompanied by the production of heat—as in a mass of wet hay—and of certain ferments, which are the active chemical agents. If we filter a fluid in which these germs are growing through porcelain we can separate the

ferments which pass through the filter, giving us a solution containing their active principles, but free from the germs themselves. These ferments are the solvent agents breaking up organic matter. A simple illustration of this solvent process is seen in the liquefaction of gelatine by many varieties of bacteria, while the breaking-up of sugar into alcohol and carbonic acid is a familiar example of the reducing process. The action of these ferments on animal matter is to break it up, and results in the formation of much simpler bodies, such as ammoniacal salts and what are known as putrefactive alkaloids or ptomaines, with which we are all too familiar. These are compounds of carbon, hydrogen, and nitrogen, with or without oxygen, and are far less complex than the animal tissues. Most are poisonous to man, some extremely so, and are frequently the cause of illness—from eating sausages, pies, and other forms of albuminous food in which putrefactive changes have been allowed to commence; and it is worth noting that they are not destroyed by heat, so that cooking, while it may kill the bacteria which produce the change, does not render decomposed meat harmless. These ptomaines must not be confounded with toxins—the poisons formed in the living body by disease-producing bacteria, such as those of cholera and diphtheria. I shall refer to toxins again in connection with protection against disease.

Putrefaction may be compared to a process of digestion of organic matter by the bacteria which feed on it. It is first liquefied and converted into ptomaines and ammoniacal bodies. These in turn are split up into simple salts and also gaseous bodies, many of which have unpleasant smells, such as sulphuretted hydrogen and other less well-known unpleasant compounds. Finally, still simpler gases are evolved, such as hydrogen, carbonic acid, and marsh gas. It is only when reduced to these simple bodies that plants can utilise the organic matter. The gases, such as carbonic acid, can be directly absorbed by the leaves. But the ammoniacal bodies have to be carried yet a step further. This is known as the process of nitrification, and the work is done by bacteria in the soil. The soluble putrefactive products are now soaked up by the soil or worked into it by earthworms and insects. The putrefactive organisms diminish, being crowded out by the nitrifying ones, before the whole of the organic matter is converted into the elemental gases. There are two sets of these nitrifiers, the first acting on the ammoniacal salts, reducing them to nitrites. The second are oxidizers, and convert the nitrites into nitrates, the form in which the plant-roots can absorb them for its nourishment. The whole of the organic matter is now gone; the plant-roots have taken up the salts and the leaves many of the gases. Other gases have escaped back to the

atmosphere, and the infective organisms and the putrefactive ones have been displaced by the normal earth dwellers, the nitrifiers.

I should mention here two varieties of bacteria which also live in the earth, and have their influence on the nitrogen for plant-food. One of these carries the reducing process too far, as it breaks up the nitrites into the simple elements and allows the nitrogen to escape back into the atmosphere, so that plants lose it. But there is the other variety, which reverses the process, taking up free nitrogen from the air and building it up into organic bodies. This form is found in the nodules which grow on the roots of leguminous plants, the nodules being formed by the germs in their growth. By thus utilising the atmospheric nitrogen these bacteria enable the legume to live in a poor soil, and the value of cropping with these plants is apparent, as by ploughing them in the soil is greatly enriched. This particular nitrogen-collecting bacterium can now be bought as a substance called "nitragen," and sown on the land.

Disinfecting the Soil.

The last of the organized material to disappear is, of course, the bones in animals and the woody fibre in plants; but they, too, ultimately decay, and are dissolved and utilised by the soil. In the process of "humification"—as this action of the surface earth has been called—many earth insects and worms play the part of tillers by turning over the upper layers, passing it through their bodies, exposing fresh layers to the action of air and light, just as the farmer does with his plough, leaving it pulverised, oxidized, and enriched. When we realise how the rich upper layers of the soil teem with this useful insect and bacterial life we understand why it has been spoken of as the "living humus," and we realise the importance of moisture and air, and how flooding with water may stop its vital processes—drowning it, as it were. In a deserted stockyard, tramped down and consolidated by the feet of cattle in wet weather and baked hard by the sun in dry, the air cannot penetrate the earth, and grass will not grow in spite of the presence of abundant manure. But in course of time the earth cracks by frost or drought, the worms begin to turn it over again, air enters, and the humifaction of the manure starts afresh.

Under Water.

In streams and ponds the same process of reduction of complex organic waste takes place. Other forms of bacterial life are at work dissolving it, and water-plants, such as cress, duckweed, seaweed, and so on, are ready to absorb the

products, while water-animals act as scavengers. So that we find an organically polluted water will in course of time get purified—unless the pollution be excessive. The putrefaction and disease-producing organisms die out under the antagonism of the normal water-living organisms, just as happens in the earth. The danger is lest we use the water for domestic purposes before the elimination process is complete. Typhoid germs die out of ordinary water standing in flasks in from three days to a fortnight. Much depends on the other organisms present.

Light, also, is an agent of power in Nature's disinfecting process. It has been shown that the numbers of organisms in a stream or lake diminish in the upper layers of water, where light penetrates freely. But the earth is the only reliable purifier for our water. It acts like the most perfect filter; but it is not a mechanical filtration. The mere straining of impure water through a gravel subsoil does not purify it to any practical extent. It is only in the upper layers—perhaps to a depth of 6 in. to 8 in.—that the work is done by the agency of the bacteria in the humus. Below a depth of 5 ft. to 6 ft. the earth is practically sterile, being devoid of these valuable nitrifying organisms. It has been repeatedly shown that outbreaks of typhoid and cholera have been due to sewage percolating through subsoil to sometimes great distances without purification. Some years ago at Worthing, in England, wells 80 ft. deep were polluted by leakage from a cesspit travelling a great distance in a fissure in the subsoil. This resulted in an outbreak of typhoid. This constitutes the danger in leaking sewers, deep cesspits, and so on. The filth is not subjected to the beneficial action of the humus filter on the surface. The manurial value of decaying organic matter is not to be judged by chemical analysis only. Certain artificial manures may be richer in nitrates than are decaying leaves; but the latter contain the nitrification agents which enable plants to use the chemical matters present, and, further, there are present certain fungoid growths which live among the roots of green-leaved plants to their mutual advantage, since these fungi can take up chemical matters and oxygen and give off carbonic acid, which the green pigment in the leaves of the larger plants absorb.

To sum up now, we see that Nature disposes of refuse in a manner both economical and efficient. The highly organized products of animal and vegetable life when dead lie on the surface of the ground, where they are attacked by forces making for disintegration—(1) Animal life, insects, &c., feeding on them; (2) bacteria, which dissolve them and decompose them into simpler bodies, and in the process kill out the disease-producing germs; (3) the humus, acting by means

of worms and insects, which work the substances into the earth; and, lastly, the nitrifying organisms, which form the simple salts and gases which the plants can take up to build once more the complicated organic tissue, so completing the cycle.

We should imitate Nature.

I have given but a brief outline of the process, which, if followed out in its entirety, would occupy a great deal of time. Many important questions remain undecided. But at least we know sufficient of the general plan Nature follows to be able, if we are alive to our duties, to copy it in our own sanitary arrangements. We cannot, I fear, do this on the same economic lines, for, however much in theory we can deplore the massing of our population in towns and cities, it is the inevitable result of civilisation, and we must face the problem of dealing with accumulations of filth which Nature never intended should exist.

Dr. Poore, whom I have already quoted, is rather an idealist in his advocacy of trusting entirely to the humus, placing all our waste on the land. He rightly considers that drainage schemes favour overcrowding, which is at the root of most sanitary sins. He has for many years at his country house in England demonstrated what may be done in a carefully tilled garden in the way of refuse disposal. In the centre of the garden is a shallow surface well, in which, owing to its carefully constructed cement walls and covering, pure water is obtained, in spite of the quantities of filth dug into the soil round about it. This is all very well when some one is in charge who can take a scientific interest in doing the work as it should be done; but I fear the result of intrusting it to the care of the population at large would be disastrous. Moreover, in few towns do even the larger houses possess sufficient land for the purpose. We must remember that, however perfect the earth may be as a filter, it will not stand overwork any more than any other form of apparatus. If we heap 2 ft. of manure on a soil having only 2 in. of humus we must not be surprised if the result is offensive. The ground will deal with a certain amount of organic matter, but it must be given a fair time in which to act. Overtax it and there will remain an amount of undecayed organic matter which will be carried by the rain either down through the subsoil to our well or washed over the surface to our streams, causing pollution. We have, therefore, to look to drainage schemes and systematic removal of filth to preserve the balance of health. The worst thing we can do with such substances is, as pointed out by Dr. Poore, to carry it past our humus

purifier by means of drain-pipes and leave it unchanged on our sea-beaches or in our streams to putrefy and pollute the neighbourhood.

HOW TOWNS SHOULD BE DEALT WITH.

In towns the pipes have to be used, however, and it is at the outfall of the sewers that we should provide systems of treatment which, in a measure, follow Nature's methods, and utilise, or at least render innocuous, the accumulated filth. There is a necessity in all such systems for keeping separate the sewage proper—that is, the waste from domestic and trade processes—from the storm-waters and natural streams. If we let them mix we have too large a volume of fluid to deal with, while at the same time the sewage is not sufficiently diluted to prevent its becoming dangerous and offensive. Unpolluted storm-water can be readily disposed of, while the sewage proper, being moderate in amount, can be submitted to any of the treatment processes which now form an essential part of all modern drainage schemes. Chief among such processes are the sewage farm, the chemical treatment, and the septic tank, or biological system.

It must be admitted with regret, as the Royal Commission on River Pollution long ago pointed out, that the sewage of towns must be treated as a nuisance to be got rid of in the cheapest and most efficient way, but must not be regarded as a source of profit. We cannot copy Nature's perfect economy when we break her rules to the extent of huddling together in large communities.

The sewage farm, to be a success, requires a large area of ground and a soil specially adapted as regards its porosity, and so on, and, though it is closely allied to natural principles, we have a difficulty in preventing our humus from being drowned unless a very large area of land be available. Thus it has been calculated that London's sewage would require a farm of 100 square miles. The chemical process is costly, and at best does not produce a very good effluent, while a difficulty remains in the disposal of the sludge, the precipitated organic matters. In the septic tank, however, every advantage is taken of the forces of Nature, the principle being to utilise the two great bacterial actions—first, the solution of organic matters, which we have seen in the decomposing body; and, second, the nitrification of the dissolved products, which we know takes place in the earth. The result is an effluent of clear fluid without smell or offence, a mere solution of nitrates and other simple salts.

Many forms of apparatus have been constructed which work on this principle, all nearly equal in efficiency. Advan-

tage is taken in this system of the fact that certain very powerful liquefying organisms only exist and act in the absence of air. For this reason the tank is closed hermetically, and the inflow and outflow pipes dip under the fluid-level and prevent ingress of air. All organic solids are liquefied in this chamber. The nitrifying organisms soon grow in the filter-beds, which are freely exposed, and the solution of ammoniacal and reduced organic products is nitrified and oxidized in the passage through the coke. When possible the effluent can be applied with advantage to the land, as it is rich in nitrates and other useful manurial salts. But if land is not available it can flow into the sea or stream without fear of offence.

Here, then, we use Nature's own processes, chained up, as it were, and working for us at our bidding, and as a result we have in this system the nearest approach to perfection yet attained in sewage treatment.

Protection.

I must now briefly mention another law by which Nature protects the public health, a law which is of interest from the fact that it is at work in our own bodies, enabling us to fight against the inroads of disease germs. There is a natural resistance of the living body against organisms which attack it. The living animal cell and the disease germ or pathogenic bacterium are engaged in a continual warfare. Probably the general health of the body has much influence on the question of which way the warfare will end, since we know that influences tending to depress the general health also tend to lay the body open to attack by such infective organisms. We know, for instance, that persons living in unwholesome surroundings are more liable to attacks of typhoid fever than those whose environment is sanitary, and this has been demonstrated experimentally with guinea-pigs. Anything tending to depress the vitality of the living cell favours the infective germ by lessening the resistance.

But Nature has another beautiful law of compensation, a law by which she makes the very life of the germ prove antagonistic to itself. It is the law which confers on us immunity from second attacks of an infectious disease. We all know that second attacks of scarlet fever, typhoid, small-pox, and so on, are rare. If it were not so, if there were no such thing as acquired immunity from such diseases, and we were to catch them as frequently as we catch cold, life would be a pretty serious matter. The secret of how Nature works this law has been an object of speculation with scientists for a long time, and we are now beginning to have some glimmering of light on the subject.

Infection occurs if the germs of disease can—(1) Live and increase in the body; (2) produce their injurious substances. It is these injurious substances, called "toxins," which produce the symptoms of disease. This we know, because we can grow in the laboratory a culture of a disease germ—say, typhoid—in broth. Then by filtering through porcelain we rid it of the actual bacteria, and yet the symptoms of the disease can be produced if we inject the germ-free broth. But if we make our culture in the living body, as it were, by infecting an animal, we can also demonstrate the formation in the blood of substances which act antagonistically to the germs and their poisons.

NATURAL IMMUNITY.

Immunity, or the power to combat disease, can be divided into two lines of resistance—(1) Natural immunity; (2) acquired. Natural immunity, the first line of resistance, is shown in certain animals which do not take special diseases. Thus cattle cannot be infected with glanders, a disease of the horse. Man does not take rinderpest, and so on. The reason for this immunity is probably merely an extension of the natural resistance all living bodies have against infection. The white corpuscles of the blood are called "phagocytes," because they eat up germs, as we can demonstrate under the microscope. Probably they secrete a sort of poison to germs, killing them first.

Guinea-pigs do not naturally suffer from typhoid, yet, as I mentioned before, by keeping them artificially in depressing conditions we can lessen their resistance until they can be infected. Certain individuals possess naturally in their blood a strong resistant power to diphtheria, so that their blood will kill such germs when we mix them together, a power not possessed, unfortunately, by all of us. This is an instance of an unusual development of the first line of resistance. Natural immunity is a subject about which we know as yet very little.

ACQUIRED IMMUNITY.

Acquired immunity is the second line, and this is attained —(1) As an after-result of the ordinary course of infectious disease, so that we do not suffer repeated attacks; (2) by artificially inoculating into the body cultures of the true or allied organisms, which in some way are rendered less virulent than normal, as in vaccination; or, again, by injecting the poisonous products of such organisms in such small doses that they do not injure us. Yet they cause a reaction in the body, leading to immunity from the disease they themselves cause.

The secret of the reaction has been followed by hundreds of scientists for many years. Briefly, we know the following facts: In the blood of man or animal which has acquired immunity we can demonstrate the existence of either one of two powers; sometimes they both exist together. These are—(1) Bactericidal power—that is, the blood can destroy the living germ in a way normal blood does not; (2) an anti-toxic power—that is, a power of neutralising the separated toxin or poison of the germ. These powers are shown against the special germ of the disease we are dealing with, but not against others, unless they are very closely allied.

The bactericidal power is found in the blood of a typhoid patient, and it is also shown to exist in even stronger amount in the spleen and glands, where it probably originates. The blood of cholera and plague patients also possesses this power, and in animals it can be developed by inoculating them with these diseases. Its existence can be readily demonstrated, and this is now done daily in the laboratory as means of diagnosing the disease. A living culture of typhoid germs examined under the microscope shows a wonderful activity. If we mix a minute quantity of blood from a typhoid patient, diluted with, say, fifty times its bulk of water, with a little of the living culture of the typhoid, and examine again under the microscope, we soon see, instead of the germs moving actively as they normally do, a slowness of their movements, till finally they become motionless, and go into clumps. If this mixture is placed in the living body of an animal we find that not only do the germs get motionless, but they are in perhaps half an hour destroyed altogether. Had the blood been that of an ordinary person the bacteria would go on living, and if the mixture were placed in the body of the animal the animal would soon develope symptoms of poisoning. Here we have the elements of immunisation against typhoid. The blood of the person who has suffered from the disease possesses a power of protecting him against further inroads, and also can be used to protect other animals. This has not yet been perfected in practice, but we know that in Africa the troops inoculated in this way showed for a time at least a partial immunity from the disease.

The anti-toxic power—that is, the existence of an antidote to the poisons which the germs secrete during their growth—is well shown in the case of diphtheria. The anti-toxin acts not on the germ, but on its products. This anti-toxin can be manufactured by inoculating living animals (the horse is generally used) with small doses of the toxins which form in artificial cultures of living germs. If we give too big a dose the animal will die, but if we begin with a small dose and gradually increase it the animal acquires an immunity until

it will stand immense amounts of the poison. Then its blood possesses the power of acting as an antidote to either the germ itself or its poison. This has, as we all know, been most successfully done, and we possess in this anti-toxin a most powerful curative agent for this disease. This antidotal power can easily be demonstrated. It is as apparent as the neutralising power of acids and alkalis. Mix a certain amount of the toxin with anti-toxin in a test-tube, inject the mixture into a guinea-pig, and no effect will follow. If the toxin alone were introduced the guinea-pig would very soon die. So, too, in the living body we can show it, by injecting two animals with the living germ of diphtheria and subsequently injecting into one of them a suitable dose of the serum of the horse previously treated with toxin. In a day or two the animal which received the germ alone will be dead; the other, which also got the anti-toxin, will live. This has been done so repeatedly for many years that there is now no question about it. The same result always follows. Wherein lies this anti-toxin power is a subject of much speculation. It is as though the cells of the living body could be trained by gradually exercising their normally existing powers to produce an excess of the material which is antagonistic to the germs and their products. This is the theory of a German scientist named Ehrlich. The fact remains, however, that we can educate the body of the animal artificially to increase its resistance, and utilise the blood of this educated animal to assist others in the fight against disease, herein following Nature's lead, where she provides that any living body, if it survive the first attack of a disease germ, possesses an increased power of resistance against further incursions of that germ. We merely exaggerate the process in one animal and use the resulting products to aid others.

It is possible that Nature too has a system of inoculation without actually producing the disease. We know at least that persons living in a country in which some disease is prevalent will acquire a certain degree of immunity without actually suffering from that disease—at least, in any recognisable degree. This is the case with malaria, yellow fever, and typhoid. Persons coming newly to a country where these diseases prevail are more liable to infection than those born and brought up there. Perhaps there has been a series of slight inoculations, as it were, with small or weakened doses of the disease, not sufficient to produce more than a passing indisposition, but sufficient to help in educating the tissues. Be this as it may, we have Nature's own methods to guide us and encourage us to further efforts in the direction of artificially gaining immunity. The best proved example is in vaccination against smallpox, where we use an allied disease

of mild type to educate the body to resist the more serious one. In diphtheria and erysipelas the curative agents are now within our grasp. In typhoid, plague, and cholera the object will, in all probability, shortly be attained, and so on. If, however, we fail to follow Nature's guidance; if we do not benefit by her lessons as to removing the causes tending to disease; if we allow our populations to grow up in conditions depressing to the system and lessening the power of resistance; and, finally, if we fail to accept her gifts in the matter of the agents which will increase that resistance, then we must be prepared to suffer the inevitable consequences. Wasteful methods of disposing of our cast-off products may be unavoidable in modern civilisation; but we can at least waste them in a clean way, and avoid fouling our sea-beaches and rivers, and polluting our air and our water supplies. We can bring up the young with clean food and pure air, and teach them to keep their bodies in health, and we can finally supplement their natural resistance to disease by such means as Nature has put within our grasp.

What we ought to do.

This is a new country, and we have here Nature at her best, working for our benefit in the matter of sunlight and open spaces, and we have the experience of past generations to guide us. Is it not a pity that we should begin at the beginning again, and pass through all the weary process of instruction which older countries have undergone in the matter of epidemics of disease? We place our sanitary work in the hands of administrators often careless or ignorant, and listen to the idle fears and prejudices of faddists, who do not take the trouble to follow the history or principles of inoculation against disease and are wilfully blind to its results. We are now, as regards sanitation in all its branches, where England stood fifty years ago, and it will follow that our lesson will be forced on us only after suffering the full penalties for ignoring Nature's law.

ART. XI.—*Technical and Scientific Training.*

By H. HILL, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Institute in August, 1902.*]

IN continuation of my paper on "University and Science Work in New Zealand,"* which found a place in the Transactions of last year, I desire to review with more brevity the present state of science in this country. We have been so attracted by events in the world outside our own country that for some time past science and many other things have been overlooked. However, necessity will soon bring things back into their proper course, and the time is not far distant when it will be found needful to consider what this country must do in order to place the coming generation on such a footing that in the race for place and power among the nations of civilised men we shall be able to hold our own so far as concerns ourselves and our interests. And here it is of importance to remind those who occupy themselves in the consideration of matters affecting the common weal that, whether we will or no, environment is an important factor in the consideration of questions bearing upon thought and action. Hitherto the country has been mainly under the direction of men of no practical training and scientific experience. Literary qualifications have been considered sufficient, and our public scheme of education is merely the outcome of literary ideals as distinguished from practical or technical skill. The people in this country are amenable to conditions which they are in a large measure unable to modify, and which Nature herself compels us to watch and to study if we would participate in all that is of the best and purest among the gifts offered to us.

The successful man is he who adapts himself to his environment. Each country has an environment that is specially its own. Conditions operate in such a way that thought, aspirations, and tastes vary among different peoples, and everywhere are to be seen adaptations to environment such as time has brought and is bringing about. When we come to realise how wide are the differences in the social, the industrial, and even in the moral and religious aspects of people who dwell in lands apart from one another, the question at once forces itself upon us whether the same kind of training should be adopted in the right upbringing of the children. A country's needs are various, and in a large

* Trans. N.Z. Inst., vol. xxxiii., pp. 395–406.

measure they are specialised. The people of England have slowly changed their habits and their ways of living because the economic conditions of the country have so altered that what was a necessity at one period of the country's history has now been replaced by some other compelling needs. A hundred influences external to the people of every civilised country are now operating and compelling lines of action and modifications of thought different from what was possible and even necessary. England, for example, do what she will, is being so influenced by external conditions that she is compelled to specialise her industries, so that a worker is merely a finisher of some portion or part of a manufactured article. The growth of the industrial arts and the intercourse between nations are bringing about this new aspect of specialisation. The workshops of the world proceed from the general to the special, and the highest differentiations in the industrial world constitute to-day the greatest specialisation of scientific training.

A brief consideration of the conditions existing in countries like England and France will show that where there are aggregations of people there are of necessity great differentiations in their industrial pursuits, and specialisation exists as a consequence of the differentiations. A new country like our own, in its social and industrial needs, does not call for the complex conditions in the production of wealth such as are called for in the countries named. In a new country wealth is made up mainly of what are known as "raw products"—the direct gifts of the earth.

The industrial warfare in a complex system of society is only possible where there is an assured supply of food products from lands where population is small; and the closer the connection between the two the greater can become the specialisation in production and knowledge. In New Zealand the staple productions are wool, wheat, meat, butter, and cheese. Manufactures form but an insignificant portion of the actual products of the country. The occupancy of the land for sustenance and for production of raw products was the first thought of the early settlers, and it has been so always. The new and the old, whether lands or peoples, act and react upon each other by means of intercourse Isolation acts upon a people as powerfully as intercourse, but in a different way. Intercourse tends to modify the direct effects of environment; but, no matter how free the intercourse, the thoughts and aspirations of a people will always be directly modified by their immediate surroundings. Thus the aims and aspirations of the English people differ from those of the people on the European Continent just as they differ from those of the colonies. It cannot be otherwise. The mind in

a large measure is a reflex of early precepts, and although nationality is something, intercourse is something, latitude is something, the fact remains that "we are what we are" as the outcome of our early associations, whether viewed physically, mentally, or morally. Circumstance has no master, and these conditions that operate in self-preservation, whether as a (State) community or an individual, naturally tend to control all our subsequent activities, no matter in what direction our energies may be directed.

Thus the modern system of commercial intercourse is making the world more and more interdependent—the parts upon the whole and the whole upon the parts—but in what? Formerly a nation was self-contained and self-sustaining. Every country was occupied by its own people, who produced what was needed for their own sustenance and support. The power of self-reliance was a powerful factor in developing aspects of national character that proved of inestimable value so soon as the desire for intercourse and discovery began to manifest itself. The convenience of position has determined the growth of the commercial cities of the world; and, as the growth of new centres of industry proceeds, so will the present lines of influence become modified. Every city, primarily, is dependent in its growth and general well-being upon its position in relation to means of sustenance and prosperity; and it follows that towns in the colonies will grow according to the capacity of a district to sustain their growth by the products of the soil, either in their utilisation or in the fostering of industries. A new country may possess advantages in the way of producing certain articles, and still the best interests of that country may be served by fostering for a time the generalisation rather than the specialisation of production. It is certain that the tea-plant will flourish to perfection in this North Island of ours, and so also will the mulberry, the particular food of the silkworm; but no one that I am aware has ventured to suggest the cultivation of the tea-plant for economic purposes, and certainly it would be a difficult matter to expect the success of the silk industry as against countries like Japan, and China, and even France.

From what is here stated it will be apparent that the question as to what industry should be fostered and what disregarded is of supreme importance to the future of our country. And what is of importance to us in the consideration of questions bearing upon production is of equal importance to others when viewed from their particular standpoint. Adaptation is an attribute of success in any undertaking, either of the individual or the State; nor should we be led astray by the success that one country achieves in a certain direction and think that what one country has achieved can be equally well achieved

by every other country. If we go to nature for our lessons there will be found differentiations and adaptations everywhere, and they are ever in process and active, because whether it be in vertical or horizontal space life is dependent as much upon external as upon internal and local conditions.

The conditions of life in the British Isles and on the European Continent are such that every energy must be brought to bear on the progressive tendencies of the people. Differentiations are various and complex, and the utilisation of waste products and the specialisation of production are carried on in a way that would be deemed absurd, or even impossible, in newer and less populous lands. But competition is a hard taskmaster, and if interchange is needful in the case of ourselves, for example, it must be an interchange of food—of sustaining-power—for those things that art and science have been able to devise by the utilisation of some of nature's bounties in lands where greater differentiations have taken place. It would be hard to say how many devices have been adopted in the preparation of the young to fight their way in the world of industry such as is being made possible by means of science and art. And the means that have been and are being taken in England, and in countries where the problems of living are a hundredfold more complex than they are in this country, have already had an effect upon the thoughts and actions of many persons interested in the furtherance of education.

The claim has been put forward that because science is being fostered in England and on the European Continent therefore we in our public scheme of education should adopt a similar scheme for the benefit of the children. From what has been already stated it must be evident that the needs of the people of this country, both for to-day and to-morrow, cannot be the same as the needs of the people in other lands, where population, climate, competition, social and political life are so unlike our own. None would venture to urge that the children of any civilised land should receive no preparation for life in face of the fierce competition and struggle through which they will all have to pass. A stepping-stone is a necessity, and the duty of a State is to anticipate the manhood and womanhood of its future citizens and provide accordingly. But what are to be the characteristics of our citizenship as compared with the characteristics of those in other lands? Governments differ, laws differ, necessities differ, and citizenship differs. In New Zealand the products of the soil are largely in excess of the actual wants of the people. Nothing shows clearer than our productions how largely the individual, by means of machinery—or, in other words,

by the help of scientific methods—produces in excess of his own requirements. He is able to do this by utilising the instruments of production in the way that experience directs. The successful farmer in Manitoba might lose his all in New Zealand if he came to farm land in the same way that wins him prosperity and comfort in a country possessing a climate of much wider contrasts, such as British North America presents. And generally the same remark applies. All knowledge has a general and a special value, and in order to insure success the generalisations of science must be understood and applied, subject to varying local conditions and influences—in other words, to environment.

But there are two separate classes of science. The one, known as "pure science," pursues the study of natural phenomena, by and through the exercise of the senses. But observation brings in its train the questions, What? and How? and Why? for a mere acquaintance with an observed fact does not suffice in the pursuit of scientific inquiry. The understanding seeks to be enlightened, and the classification of facts enables inferences to be drawn, and thus provides a basis, as it were, for new lines of thought. Applied science, on the other hand, has reference to the utilisation of scientific facts for economic purposes. The science of to-day, whether natural or applied, is merely the accumulated results of the observations, discoveries, and applications made during the yesterdays of the past.

The growth of production in this country from the time when it came to be known as a land suitable for colonisation shows what is possible without the direct application of scientific methods. The accumulation of facts gained by experience—that is, the elementary application of scientific knowledge—sufficed to direct settlers to certain forms of production, and when partial success had been attained it soon became apparent that production was in excess of the requirements of the country. Intercommunication between Australia and New Zealand began, and as production increased communication was widened. Even without the aid of science in the school system of the country production increased at a rapid rate, but it arose from causes that were in a large measure external to the country itself. The accumulated wealth of England was ready to furnish capital for the production of commodities that would supply yet greater wealth to the English people, and so forms of production were fostered in New Zealand by means of which raw products were furnished to supply the manufacturing industries in England.

If we go back to the state of things in this country just twenty years ago, it will be evident to those who study

economic questions that great changes have taken place in the industrial conditions of the people since then. At that time the staple industries were in a depressed state. Nothing appeared more unpromising than the rearing of sheep. Prices were low, the wool barely sufficed to pay expenses of farming, and there was little or no demand for sheep, whilst vast numbers were annually boiled down merely for their fat. But it was at this time that applied science came to the rescue. The preservation of foods of a perishable nature was receiving the attention of scientists, and the discovery of the "chilling process" in the conveyance of fresh meat between America and England very soon led to the adoption of the "freezing-chamber" for the conveyance of frozen mutton between New Zealand and England. The application of elementary physics in the production of cold air enabled those who knew that putrefaction was stayed and all microbes destroyed at a temperature below freezing-point to realise the great benefits that must accrue by the introduction of machinery for the preservation and conveyance of perishable products. It was soon realised what an important bearing the preservation and conveyance of perishable foods like meat would have upon the markets of the world where meat was dear and was largely consumed by the people. The discovery showed how it would be possible for the industrial world in manufacturing centres to benefit by this simple application of a scientific fact to the conveyance of perishable products. But the discovery illustrated how nearly the producers of raw and of manufactured products are dependent on one another if the highest benefits are to be obtained by the application of science to production. The preservation of perishable foods and their carriage from country to country introduced a new factor in commerce, and made possible a differentiation of production such as could not have been continued under modern colonial conditions but for the discovery that enables a balance to be kept between the producers and consumers of perishable products. A country like our own need have no excess of perishable goods such as are indispensable to the maintenance and support of a high standard of civilised living.

In the year 1882 the talk was of some means of disposing of the excess of sheep, which at the time numbered about thirteen millions. A new factor comes in and so modifies the conditions that the social, the material, and the industrial state of the country is affected, and at the same time the "new factor" influences large communities separated from us by thousands of miles of intervening ocean. We have a glimpse here of the possibilities of the future when science shall regulate production and constitute the foundation of training in the upbringing of every child.

That valuable issue of the Registrar-General, the "Official Year-book," contains statistics that are worth putting on record here as showing what has been done and is being done in the country as the outcome of scientific discovery in relation to the carriage of foods of a perishable nature. Just twenty years ago the first shipment of frozen meat to England was made, and 15,244 cwt. of mutton, valued at £19,339, were sent away from New Zealand. Since then the export business of frozen meats has grown by leaps and bounds; but butter and cheese have been added to the list of exports, and it would be difficult to suggest what new products will be added to the list of articles that it will be possible to send away during the coming twenty years. Science is, in fact, becoming the handmaid of all production, and it will come to be realised as education advances that all forms of industrial progress are based upon the science of observation. Curiously, it began in the discovery of means for the more rapid utilisation of raw products; but so great has become the power of utilisation that science has now come to the help of producers by showing them along what lines they must go, and suggesting to them how their more perishable goods may be preserved and conveyed from place to place and from country to country without loss or injury. Last year the exports of frozen meats from this country, including mutton, lamb, kidneys, beef, pork, veal, rabbits, hares, poultry, and fish, reached 1,868,100 cwt., or 396,037,200 lb. avoirdupois, and valued at £2,264,120; whilst the butter and cheese sent away under similar conditions reached 305,885 cwt., or 64,847,620 lb., and valued at £1,121,091, or nearly half the value of the total meat export. Here, then, we have facts of great importance to this country in relation to its industrial, social, and commercial conditions. In twenty years, by the direct aid of science, new exports have become possible amounting to a total of £3,385,211 a year, or to more than 26½ per cent. of our total exports. If this result is not sufficient to show Parliament and those who are engaged in industrial or commercial pursuits the vast possibilities that science opens out in the way of assisting the material well-being of the people, it will be difficult to suggest a course that is likely to impress them more.

But is the country alive to the importance of scientific instruction as an instrument of production? for I take it that every scientific discovery that leads to the utilisation of the products of the land is an instrument of production from which common benefits spring. Let us see. The Farmers' Union, representing, I believe, the farming interests of the colony, have lately been in conference, and the results of their deliberations as they appear in yesterday's telegrams (8th

July) are set forth in "seven planks," and members of the union are advised to vote only for those candidates who agree to the platform of the union. Not one of the planks has even a reference to education, or to the necessity of scientific training in the preparation of future farmers along lines that are suggested by the discoveries made in agricultural science and the application of physical laws to the production and preservation of the products of the soil! With all the direct advantages that farmers reap as the outcome of scientific discovery, and in full view of the facts such as are quoted above, is it not surprising that the only thing the representatives of the farmers of New Zealand could think of as being necessary as affecting the present system of public instruction is a modification of the syllabus "that sewing may be taught to girls in all schools"? What a thing to set forth as representing the deliberations of a conference that embodies the interests of over a hundred thousand producers, and whose prospects have been so materially improved by the direct application of science to the preservation and carriage of their products to distant markets.

It will perhaps be urged that the country has adopted a scheme of science instruction for the schools and the people generally. In the year 1882 the great producers of wealth in this country were at their wits' end to find markets for their produce other than wool. Science stepped in and showed them that the preservation of perishable foods was possible. Since then the adoption of scientific methods has so enhanced the value of what were in a large measure waste products that the export of butter, cheese, and frozen meats falls little short in value of the great staple of the country, and has brought in something like £30,000,000 during the twenty years that have gone by since the frozen-meat industry began.

With these facts before us, is it possible to suppose that the farmers do not yet realise the vast possibilities awaiting them if they will adapt themselves and their offspring to the newer conditions that have arisen by the mere introduction of scientific processes in the preservation and transport of perishable foodstuffs? If they are indifferent as to the benefits science is conferring upon them, then let me quote for their edification the words of Locke that he addressed to a certain class of people "that want proofs not because they are out of their reach, but because they will not use them. . . . Nor," says this philosopher, "shall I take notice what a shame and confusion it is to the greatest contemners of knowledge to be found ignorant in things they are concerned to know. But this, at least, is worth the consideration of those who call themselves 'gentlemen': that, however they may think credit, respect, power, and authority the concomitants

of their birth and fortune, yet they will find all these still carried away from them by men of lower condition who surpass them in knowledge. They who are blind will always be led by those who see, or else fall into the ditch; and he is certainly the most subjected, the most enslaved, who is so in his understanding."

It has been pointed out that there are two separate and distinct branches of science — viz., natural and applied. Herbert Spencer, in his "First Principles," when treating of the law of evolution, remarks that at one time science was in union with art, the handmaid of religion, then passing through the era in which the sciences were so few and rudimentary as to be simultaneously cultivated by the same philosophers, and ending with the era in which the genera and species are so numerous that few can enumerate them, and no one can adequately grasp even one genus.

Here, then, we are brought face to face with the inquiry that if the genera and species of the sciences are so numerous, how can a scheme of public education deal with a subject so vast and so various in its aspects and ramifications? The Manual and Technical Instruction Act that was passed in October, 1900, is made to form a "part of, and be read together with, 'The Education Act, 1877.'" On paper it would seem that New Zealand has a scheme of public education that provides for the primary and the manual and technical instruction and training of the children in the public schools. Admirable in themselves as these forms of instruction appear, they represent what we have been accustomed to so long—the product of inexperience and immature thought. To read the regulations issued under the Manual and Technical Act one would imagine New Zealand to be an old-settled country with an immense urban population engaged in a hard struggle to live, where necessity has driven the authorities to introduce into the primary-school course and into every aspect of school life as many genera and species of science as are recognised in England by the Science and Art Department. We are far from being an industrial community, and of the bread-winners the professional class numbers 23,509; domestic, 34,394; commercial, 39,937; transport and communication, 21,750; agricultural and pastoral, 111,921; whilst the industrial numbers 101,184. Of the professional class 6,026 are returned as ministering to education, but how many of them are capable of giving instruction in science except such as is obtainable from books? The fact is that our legislation on education is fashionable, and presents to the world outside a semblance of progress that facts do not warrant.

Under section 84 of "The Education Act, 1877," eleven

subjects are enumerated in the standard work for boys and twelve for girls. To these is added military drill for boys and "physical training" for girls. Under "The Manual and Technical Act, 1900," "school classes" may take in addition, under Regulation 19, a variety of subjects for children below Standard III.; under Regulation 21 Standards III. to IV. may take subjects including "bricklaying" (including the necessary drawing); whilst in the two highest standards subjects may be taken (of so various a character that it would be a difficult matter to say what) including agriculture, chemistry, physics, botany, geology, and physiography, and the wonder is under what conditions the subjects are to be taught. There is a minimum of twenty hours in a school week, and our modern and model scheme of public education deems it possible to teach some of the subjects enumerated in the Manual and Technical Act in addition to the dozen compulsory subjects enumerated in section 84 of the Education Act. In order to foster the introduction of this "special instruction" there has been added to our "free system" of education a capitation system of payment, by which I suppose it is thought that the "special classes" under the Act of 1900 will make headway somehow in the school course.

I do not think any one will be found to suggest that I am not anxious to see everything done for the benefit of our children, so as to prepare them for the time when they will be called upon to play their parts in this world of action, of competition, and enterprise. My anxiety is that the best efforts of parents, of teachers, and of educationists generally should be directed to the proper upbringing of the children for the fulfilment of duty, whether it be as a citizen, as a merchant, a manufacturer, a workman, or even as a politician. Now, the question is, Does the Manual and Technical Act, in combination with the Education Act of 1877, aim to do this?

In the year 1889 a Technical Instruction Act was passed in England. Section 8 of that Act defines "technical instruction" to be "instruction in the principles of science and art applicable to industries, and in the application of special branches of science and art to specific industries or employments," and the expression "manual instruction" is defined as "instruction in the use of tools, processes of agriculture, and modelling in clay, wood, or other material." The definitions used in our Manual and Technical Instruction Act are evidently taken from the English Act, except that in the interpretation of the term "manual instruction" the words "such exercises as shall train the hand in conjunction with the eye and brain" have been added, much to the weakness of the definition, for it would be difficult to conceive the hand

being trained without the aid of the brain acting through one of the senses.

A Commission appointed by the legislature of Pennsylvania to inquire into the subject of scientific education, has defined "technical instruction" to be "the teaching of science with specific reference to its industrial application, and, as a term, is almost universally applied to the higher ranges of such instruction"; and manual training is thus dealt with: "'Manual training' in the strict sense of the term would mean simply the training of the hand, but as currently used with reference to education the words indicate such employment of the hand as will at the same time train the eye(?) to accuracy and the mind to attention. The scientific element, or the teaching of science pure and simple, is not necessarily involved in the expression. As, however, pure science can scarcely be taught without looking somewhat towards its applications, so manual training cannot be made an effective educational process except by constant reference to the broad foundations in the mathematical, physical, and natural sciences upon which it rests." I might easily add to these definitions to show how really uncertain we are even now as educationists as to what we mean by the terms "technical instruction" and "manual training." I confess that my definition of either form of instruction would not agree with what is accepted in England.

But the fact is we are in the hands of the Philistines. It has become fashionable to change and add ornaments(?) to our system of education, and, without considering what is really necessary to place our system on a foundation of its own, adapted and adaptable to modifying conditions of environment, we have taken our cue from the Motherland, where conditions are very unlike our own. Let any one take up the English blue-book, such as is issued by the Board of Education in London, and there will be no doubt as to what is intended by the syllabuses of instruction that may be taken and taught in the night schools, the continuation schools, and the upper or secondary schools of that country. England is supremely an industrial country. She is sustained by her manufacturing superiority; but competition is so keen, internal and external alike, that every circumstance that adds to the utilisation at an earlier period of the youthful material as it comes from the schools, and everything that can be done to help motherhood in nursing her offspring so that she may toil in the factory, and in assisting young men and women to become more skilful in their industrial work, is done by the State. To England industrial skill, manipulative and scientific, is everything. It means work, bread, comfort, success, power,

and influence. It means the supremacy of England in directing the trade, and in a large measure the government, of the world.

And observe what effect this trending of education to competitive necessity is having on the upbringing of young children: "Half-time scholars should not be subjected to any system of exercise or drill which, if practised in the morning, might render them unfit for their afternoon's labour, or, if practised in the afternoon, might press heavily upon a tired boy or girl." These words are quoted from the "Revised Instructions" of the English code of 1899, page 659, with reference to physical exercises, and they suffice to show what so-called primary education is becoming in England as interpreted in the public-school system of that country. The schools are already little less than preparatory workshops to meet the stress of industrial competition, and an "instruction" such as is here quoted shows the tendency of the so-called technical and manual form of instruction in countries where competition is a case of life and death.

But are we in this country called upon to adopt a similar scheme of training for the children of our public schools? It has already been explained that environment is an important factor in the education of the people, and that our needs and our ways of living, and even our national aspirations, differ from the ways and needs and aspirations of people who live in other lands. It may be that the course of instruction adopted in the public schools of England and Germany is best suited for the present needs of those countries, but is it to be said that what is good for England and Germany is therefore good for us? The case of the boys and the frogs as told by Æsop should give us the answer.

What, then, are we in this country to do if we may not accept the schemes of education such as other Governments have adopted for the benefit of their people? The answer is an easy one. We must provide a scheme adaptive and adaptable to our own ever-varying conditions, where the law of evolution will operate and education will be modified to meet environment as presented in the unlike conditions that now exist in the colony. We must foster a knowledge of natural science among the teachers so far as relates to local and even colonial environment, and we must have teachers prepared as teachers in anticipation of the profession they are to follow. Our country sadly lacks teaching experience and skill, and the two training institutions in the South Island are certainly running along on unscientific lines. There is an abundant supply of bookmen who teach the book, the whole book, and nothing but the book, but who are ignorant of the great book of nature,

of which we need so much to encourage the study among children. Mere book knowledge makes a good show to the outside world, which only reads of examination results; but teachers who know nature even as far as their surroundings, and who can interest children not alone in the dead past but in the more important living present, are badly wanted by this country, and they must be obtained if our education is to be anything better than the mere varnish of knowledge. The industries, the scientific progress, the material, and even the social and political status of the country are in the hands of the six thousand or so teachers who are occupied in the noble work of education. Provision must be made for the training of teachers in technical skill apart from mere academic instruction; and this must not be on the antiquated lines of "normal schools," such as were established in England and elsewhere when provision was first made to prepare teachers suitable for the elementary instruction then deemed sufficient.

Our schools are "national" in the fullest meaning of the word. They are established and maintained by the country, and it is assumed that all the children of the State pass through them. It is essential, therefore, that the best skill obtainable should be found in the public schools, so that the best influences can be brought to bear upon the right upbringing of the coming democracy. The duty of the country is clear upon this point, and the sooner properly equipped technical schools for the training of teachers are established the sooner are we likely to have men and women working in the schools who are able to utilise all the surroundings of the children in the acquisition of knowledge and the utilisation of books. At present our scheme of public instruction lacks coordination and simplification. It has even now become intricate, and the passing of the Manual and Technical Act of 1900, with its recent amendments, has intensified the difficulties.

But how complex already are our ways of providing elementary education for less than a hundred and fifty thousand children and adults in this colony. There is a central Department of Education in Wellington, with many clerks; there are fourteen Education Boards, with secretaries, clerks, architects, and inspectors of schools; there are school committees, truant officers, &c., and all this is for the regulation and training of about a hundred and twenty thousand children! Then, for the secondary schools there are Boards of Governors, with large endowments of lands subject to their control; there are School Commissioners, who manage primary-education reserves and secondary reserves that have not yet been made over to Boards of Governors having charge of high

schools. Then, there are governors of university colleges, technical and art schools; and, finally, there is the University, administered by a Senate—but all, from start to finish, being maintained out of public endowments of land or by means of special grants out of the Consolidated Fund. It would be an interesting inquiry as to the cost of providing the machinery for the education of a mere handful of children; and yet how much could be saved by effective organization and a better grasp of the principles that should regulate the administrative work of this great and vital question of public education.

Much could be said in favour of the independence of control which is such a characteristic of the secondary and higher education of the country; but to be consistent the plan should be widened so as to embrace the primary schools. Then it would be possible to lay the foundation of an adaptive scheme of public education in the colony. At present adaptation is impossible. It cannot even be encouraged, for the standards of education that operate in the primary schools make it a matter of impossibility for the children to take up work outside the regulations, and every pupil must pass through the same "eye of the needle," known as the Sixth Standard course. Were such a change made there would still be a regulating central authority; but this authority, whilst it supervised and fostered all forms of education from the cradle to the university, should allow free play along lines adapted to the industrial, the commercial, and the agricultural necessities of districts. The same right of taking the initiative should belong to every district, subject always to the supervising control of the central authority, whose inspectors should be men not merely of school-book attainments, but capable of determining the quality of education in its bearing upon the training of pupils in all those qualities that make for morality, manliness, refinement, and national prosperity.

Under a scheme such as is here outlined there would be no need for standards of instruction like those now in operation. Beyond the study of arithmetic, drawing, and English, including reading, writing, and composition, each school district would have the right to recommend for approval a course of instruction that in the opinion of the people would best meet the wants of the people. Special and school classes would disappear, for the work selected would be the best suited to the requirements of a district. As for science, pure or applied, the latter would be left, as it ought to be left, to the time when pupils quit the lower schools; but natural science would form, as it ought to form, the groundwork of all early training and education. The study of natural phenomena,

the quickening of observation, the collecting of facts, and the constant reference to the "why" in the cultivation of the faculties of the children, ought to form the very groundwork of all the earlier training in the schools. Minds led along the paths such as nature designed for them will pursue the study of natural science as a pleasing recreation if only teachers themselves lead the way. The clouds in the sky, the phenomena of rain, hail, snow, wind, thunder, lightning, heat, cold, and a hundred similar things, provide a field of training such as no books can supply. Air, earth, water, animal and vegetable life provide facts that are available for all forms of science and all departments of discovery and invention; yet these, though so full of sermons to young minds, are passed by for the purpose of acquainting children with statements made in books, which in too many cases teachers and pupils have no means of proving or disproving.

The training in natural science such as is suggested here gives power to children. They are early led to see and to think for themselves, and if teachers paid more attention in the schools to this aspect of learning, school life would be rid of half its difficulties, and progress would be more real because more permanent and capable of producing means of instruction and enjoyment. Professor Huxley once said, "I would not turn my hand over to have biology taught in every school in the land if the subject is to be taught through books only"; and it appears to me that no one should be placed in charge of a public school who is unable to train children by the direct exercise of their perceptive faculties. Observation represents experience. It deals with realities, trains the judgment, encourages work, and provides a means of daily pleasure to children by placing in their hands the means to discover new facts. Thus natural science becomes the stepping-stone to the utilities in experimental science in all that pertains to industrial and economic conditions.

It will be noticed from these observations that science begins, or should begin, in the infant schools, and it should be continued in an ever-widening circle throughout the primary or lower school course. A degree of specialisation could then be introduced; but under no circumstances should science as applied to the arts and industries be made to form a part of the instruction to be given in a public school. Intelligent children, trained to observe and to express their thoughts, are capable of pursuing an advanced course of instruction such as will fit them to pursue with success such forms of industrial life as are found in this country. New Zealand, as remarked above, is not a manufacturing country, and it is manifestly improper for children to undergo a preparation for a form of industry not carried

on in the country. Manufactures are few and the industrial interests small when compared with the agricultural and pastoral, so that, whatever specialisation may be found necessary, it should be in the direction of improving those interests that are of the greatest moment to the country. Hence the study of natural science should be fostered even beyond the public-school course, and this can readily be done by the introduction of botany, geology, agricultural chemistry, and other cognate subjects into the advanced or secondary course. The maintenance by the Government of technical schools and schools of science and agriculture would give prestige to such institutions, and these, with the university colleges, should supply all the academic, scientific, and technical training that is wanted for the professions and the pursuit of every specialised form of industrial work.

Our country has the making of a perfect scheme of training, but the need at present is to distinguish clearly between the mere academic preparation and the technical training of a specialised character. Thus, the young doctor may attend the university college classes for academic requirements; but it is necessary to have a practical acquaintance with physical ailments of humankind—hence the necessity of hospital training and practice. It is the same in the case of teachers, lawyers, electric engineers, and, in fact, all the professions. The country, however, has not yet come to see how well the university colleges, under proper direction, can easily supply all the academic preparation, and may supply the scientific; but they cannot supply the technical, and it is the technical aspect of training that this country stands so much in need of to-day. Efficiency is the outcome of technical training adapted to meet the special needs of a country, and it must be confessed that little has yet been done in this direction to prepare our young people for the professions as distinguished from trades. The training for citizenship should be based on scientific lines. From the general to the special, from natural phenomena to natural science, and from natural science and research to special and applied science, such is the order of preparation if the country is to derive the best results from its public schemes of education.

A good deal remains to be done for the children and the teachers before it can be said that the education of the people is on a scientific and therefore an efficient basis. I have briefly indicated the direction along which a new departure is needed in the work of the primary, secondary, and university institutions of this country.

ART. XII.—*The Maoris To-day and To-morrow.* (No. 2.)

By H. HILL, B.A., F.G.S.

[*Read before the Hawke's Bay Philosophical Institute, 13th October, 1902.*]

THERE is something fascinating in the Maori race. As a people they win the sympathy of every lover of humankind. Brave, generous, thriftless, courteous, and unstable, such are their characteristics when left to themselves, but under the higher influences of civilisation they are progressive, intelligent, appreciative, and ambitious. Few peoples have had so much written of them during the comparatively few years they have been in contact with the higher civilisation of the world. Americans, Frenchmen, Austrians, Germans, Englishmen, and colonists alike have written of them, praising and blaming according to circumstances of time and place. As one who has studied their characteristics for many years, and coming in contact as I do with them along the whole of the East Coast as far as Cape Runaway, I have little but praise to bestow upon this fading but noble race of people. A mere handful amidst the conflicting influences of a new social and political environment, there is little wonder that they should have misunderstood and have been misunderstood by colonists. The conflicts that have taken place since the incoming of Europeans into their land have only tended to bring out more prominently their leading characteristics. Until the latter quarter of the nineteenth century they were a factor to be considered by colonists, but of late their advancing civilisation(?) and their diminution have tended to lessen anxiety, until at the present time no one thinks that any danger is likely to result from disaffection among isolated hapus to be found among the Ureweras or other of the native tribes.

The interest in the native race to-day is mainly centred in the question of their probable continuance as a people and a nation. Contact with a higher civilisation has not always been of benefit to a conquered people, and the question has more than once been discussed as to whether the Maori race is doomed to disappear before the advancing strides of civilised Saxondom. In discussing the probabilities surrounding this interesting subject it may be well to inquire into matters

of native life and ways that throw us back to the days when few dwelt in New Zealand other than natives and missionaries, and we shall see how far changes have been made in the Maori forms of social life such as are likely to benefit the race and be counted as factors in estimating the possibilities of their continuance as a living force among the colonists.

The returns of the census that was taken in the month of February, 1901, have now been published, and it would appear from a memorandum, to the Hon. the Native Minister, appended to Maori census returns by Mr. Under-Secretary Waldegrave, that there has actually been an increase in the Maori population since 1896, when the previous census was taken, of over 8 per cent.; in other words, the native population is stated as having risen from 39,854 in 1896 to 43,101 in 1901. This result, it must be confessed, is most satisfactory as far as figures are concerned, and when at the same time the returns of the population show a marked diminution in the number of half-castes there is reason to hope that the influences working for the betterment of the native race may yet have the effect of staying their decadence and early disappearance, such as has already come about in the case of the Tasmanian natives. But although the census returns have evidently been arranged and carried out with much care by the official enumerators in the several districts, and possibly few errors have been made, it is still very doubtful whether the returns that have been made and published at former periods when the census has been taken were more than mere approximations. In 1867 the estimated population of the native race was returned at 38,540, and in 1871 at 37,520. When the first census attempted by the Colonial Government was made in 1874 the returns gave 45,470 as the native population, and in 1891 the numbers had fallen to 41,993. Then in 1896, as already explained, the statistics of population gave only 39,854; but since then a change has taken place of so marked a character that it would appear as if some cause had been operating to stay the constant diminution of population such as previous censuses from 1874 had shown to be going on. No one who is acquainted with the homes of the natives can doubt for a moment that wherever there has been contact with the Europeans improvements in many ways have taken place; but habit is a difficult thing to overcome, and men and women who have lived under certain conditions for half a lifetime are not likely to change suddenly their mode of living by merely listening to what their children tell them of hygiene and the way to maintain good health.

The Rev. William Yate, in 1835, wrote in his book

on New Zealand: "There are comparatively but few old people in New Zealand—scarcely any who have much exceeded fifty years of age. War, accidents, diseases have made sad havoc among them"; but just as the *tohunga* is to-day looked upon with favour and trustfulness by the older natives, even beyond the powers of the medical practitioner of the colonists, so in the matter of living the natives who at present dwell in isolated and remote districts look upon their ancestors as their ideals and type, and they prefer to follow their ways and customs rather than hearken to what the children have to say who are taught by the pakeha, and who do not know the ways of the great ancestors of their race. Yet it is the new influence that is the more active. The schools modify thought, and the old legends and tales of the pa are neglected or forgotten for the tales and stories told in the reading-books. Intercourse with the Europeans, the power to use the English language, and the formation of early habits of thought in English are all tending to the assimilation of the Maori. He reads Hans Andersen's fairy stories, but is not made aware of the stirring episodes in the history of his own people, and of the beautiful stories and legends that adorn the history of his own race. Surely the assimilative process is active in the school life of the children. But has the Maori race ever increased in the land so much as to make it probable that as a people they may yet be able to maintain a position in the country in face of the new forces that are operating under the controlling influence of Saxondom? The answer is one of doubt. Every year the relative position of the Maori and the colonist is changing. Even when there is an increase of the native population it cannot compare with the proportionate increase among the colonists, and although there is a process of assimilation going on it is more apparent than real.

We are not in possession of sufficient evidence to guide us as to the population of Morioris who once lived in New Zealand, but who now are limited to the Chatham Islands, and number, according to the census, thirteen of pure blood and eighteen half-caste Moriori and Maori. Nor are we sure as to the time when they were overcome by the Maoris, who drove them southward; but when the Europeans first came into contact with the New-Zealanders the northern and eastern coasts of the North Island were the most populous, although settlement had taken place towards the interior and within the precincts of the volcanic area. The settlements in the Rotorua, Taupo, and Tokaanu districts imply, it seems to me, a much longer dwelling in the land than is generally supposed. The natives are naturally subject to peculiar fears. The darkness to them typifies the unseen, the un-

known, danger, vengeance, death. They dread the influence of the *atua*, for every bad event, whether of fear, or pain, or disease, was the outcome of anger on the part of an active avenger, who to them only manifested himself to show displeasure, resentment, or vengeance. Taupo was in truth a place of darkness; but at the time of the incoming of the colonists all its terrors to the natives had passed away, and the unknown and dreaded forces which manifest themselves within the volcanic zone from time to time had little or no dread for the thousands of natives who resided within the limits of devastating influences of the active volcanoes of Tongariro, Ngauruhoe, Ruapehu, and Edgecumbe.

And, as showing the long residence of the natives in the country, the legends concerning the extinct volcanoes of Pihanga, near Tokaanu, of Egmont, in Taranaki, and of Tongariro and Ngauruhoe, imply settlement in the vicinity of the volcanoes at the time of great activity, such as must have modified very largely the topographical aspects of the country. One legend runs to the effect that Egmont at one time stood on the spot now known as Lake Roto-aira, that Tongariro was in love with Pihanga, and that Egmont, having made improper advances to Pihanga, was struck by Tongariro and forced to flee to where he now stands. Of the volcano Ngauruhoe the story runs "that when Ngatororirangi, the chief priest, or *tohunga*, who piloted the 'Arawa' canoe from Hawaiki, with Tia, another great chief, took possession of the country extending from the Bay of Islands to Ruapehu for his people, he ascended Ngauruhoe (which at that time was not a volcano) to perform his needful incantations. In accordance with Maori rites he set up a *tuahu*, or altar, so as to insure to his people the possession of the country and a happy and fruitful future. When in the midst of his *karakias*, or incantations, the cold was so intense that it seemed as if he must die. It then occurred to him to send for the sacred fire, which was kept during his absence in the custody of his sisters, Hoata and Pupu. Seeing them at that moment on Whakaari, or White Island [120 miles], he urged them to bring the fire if they would save him from perishing. In response one of his sisters dived into the sea in the direction of Tongariro, and reached her starving brother in time to save him from a cruel death. In her passage underground she set fire to the world below, hence the hot springs, puias, fumeroles, &c., in the line of route. In commemoration of the event Ngatororirangi left the sacred fire burning in the mountain." Then, again, the word "Ruapehu" implies a shattering or a breaking to pieces, and it may have been that the name was given in response to the explosions and the ejection of stones of many varie-

ties such as have no doubt been cast from the mountain at different times and of which the Rangipo Desert bears full testimony. These legends concerning the volcanic area, which might easily be increased, imply a long residence in the country, for clearly great changes must have taken place in the surface features of the entire district extending from the Bay of Plenty to Ruapehu, and even to Taranaki, and yet everything is embraced in the period since the arrival of the *tohunga* who led the "Arawa" canoe to the shores of New Zealand.

But, notwithstanding the long residence of the Maoris, they do not appear to have ever reached in population the numbers to be found in a third- or fourth-rate town in England. The Rev. Mr. Yate, in "An Account of New Zealand," published in 1835, says (page 164), "The population of the whole northern island may, perhaps, be taken at one hundred and sixty thousand, though possibly there may be more. Twenty-eight thousand would, perhaps, be the utmost extent of numbers from the Bay [of Islands], taking in all tribes connected with it, down to the North Cape. . . . We know the total number of fighting-men in the northern island to be about forty thousand, and the number in the neighbourhood of the Bay and northward to be about seven thousand. What number there may be in the southern island we have hitherto had no means of ascertaining."

As far as I can trace, the first estimate of the native population based upon a division of the Island into districts was made by the Rev. James Hamlin in the year 1842. His purpose was to show the actual number of fighting-men in the North Island, and he bases his estimate upon the number of births that had come under his immediate notice as a missionary and the number of those who survived in a certain hapu with which he was intimately acquainted. Knowing all the men and women of the hapu, he took careful count of the number of births and deaths during a given period, and then made an estimate of the fighting-men that would be available from the hapu, and then, dividing the whole of the Island into twenty-one districts, he gave an estimate of the population and of the probable number of fighting-men in the country. The information supplied by Mr. Hamlin appears to me as being of much public interest in connection with the Maori race; and, as the information is not easily available, I shall quote the facts here for the benefit of future students with a turn for statistics bearing upon the natives. "Perhaps," says Mr. Hamlin, "the number of families I have written down,

with the number of children born and those who are now alive, will give us an idea of the number born and of the proportionate number of deaths:—

—	Born.	Killed.	Died.	Now alive.
Eight families grown up ...	63	2	38	23
Nine families young ...	28	0	17	11
Nine families young ...	26	1	12	13

These families have not been selected, but have been taken in little parties as they sat together. . . . It has been observed that two-thirds of the deaths in New Zealand take place under twenty years of age. If this is the case, I think half of them occur in infancy. Within a fortnight of our Sophia's birth, either before or after, there were five native children born of natives living near us, only one of whom is now alive. These died within six months of their birth. The one who is now alive was medicined and fed by us when he was ill. Some of the New-Zealanders have a great many children born—some as many as fourteen, others fifteen, and a few have had twenty; nor are these occurrences rare, and yet if five or six of these arrive at middle age it is considered a large family. When something of the kind was mentioned some time ago I was unwilling to admit the fact, but from my own observation I find it is the case. From 1835 to 1838 it was considered that the population decreased, but from 1838 to 1841 it has increased. If a reason be asked why so many of the New-Zealanders die in infancy, I should answer, first, from the idleness, negligence, and thoughtlessness of the mothers; and, secondly, from want of proper food and clothing. Some persons may perhaps think it difficult to reconcile the first of these with the hypothesis that generally prevails that the New-Zealanders in general are fond of their children. While this is the case, it is also true that they are very careless, inconsistent, and, I should in justice to them say, ignorant mothers. . . . With regard to the fighting-men, I think the natives are very correct in general in giving the number in each tribe. I subjoin a calculation of the number of inhabitants in each district and throughout the Island:—

District, Station, and Location.	Fighting-men.	Total Inhabitants.
1. Church Missionary station, East and West Coasts, Northern district; tribe, Raraua	1,500	4,500
2. West Coast, Wesleyan Missionary station, Hokianga district; Ngapuhi or Hokianga	1,200	3,600
3. East Coast, Church Missionary station, Bay of Islands, two districts, Taramai and Waimate; tribe, Ngapuhi	2,400	7,200
4. West Coast, Wesleyan Missionary station; Kaipara and Wairoa	400	1,200
5. West Coast, Church Missionary station, Waikato and Manukau; tribe, Waikato	6,000	18,000
6. East Coast, Church Missionary station, Thames district; tribe, Ngatimaru	1,300	3,900
7. East Coast, Church Missionary station, Tauranga district, Bay of Plenty; tribe, Ngatiawa	700	2,100
8. East Coast (inland), Church Missionary station, Rotorua district; tribe, Ngatiwakawe	4,500	13,500
9. Middle of Island, Church Missionary station, Taupo district; tribe, Ngatituwaretoa	600	1,800
10. East Coast, Bay of Plenty, Whakatane district, Church Missionary Society; tribe, Ngatiawa	1,460	4,380
11. East Coast, Bay of Plenty, Opotiki district, Church Missionary Society; tribe, Wakatohea	800	2,400
12. East Coast (inland from Whakatane), Church Missionary Society; tribe, Urewera	1,000	3,000
13. East Coast, near Cape Runaway, Church Missionary Society, Torere district; tribe, Ngatiawa	1,200	3,600
14. West Coast, Wesleyan Missionary Society, Taranaki district; tribe, Ngatiawa	60	180
15. West Coast, Wesleyan Missionary Society, about Egmont; tribe, Taranaki	1,000	3,000
16. West Coast, Wesleyan Missionary Society, south of Egmont; tribe, Ngatiruanui	1,200	3,600
17. West Coast, Church Missionary Society, Wanganui district; tribe, Wanganui	1,800	5,400
18. West Coast, Church Missionary Society, Kapiti and adjacent district; tribe, Ngatitoa	1,000	3,000
19. South (Port Nicholson) and towards East Coast, Wesleyan Missionary Society; tribe, Ngatiawa	1,000	3,000
20. East Coast, Church Missionary Society, Mahia and Nukutaurua district	4,040	12,120
21. East Coast, Church Missionary Society, Waiapu district; tribe, Ngapaeruru	6,000	18,000
Tate Apuree(?) Haikeke (between Port Nicholson and East Cape?)	200	600
Supposed to be inland, and imperfectly known to Europeans	640	1,920
Grand totals	40,000	120,000

It will be noticed that Mr. Yate's estimate in 1835 exceeds that of Mr. Hamlin's in 1842 by 40,000, whilst the

number of fighting-men in each case is the same. Between 1835 and 1842 the country was very much disturbed, and fighting was frequent and fierce. But Mr. Hamlin had many opportunities of gaining information, and his figures may be accepted as approximately correct.

Sir George Grey, when Governor of the colony in 1851, accepted the estimate in his letters to the Home Government, and he had the best means of obtaining information at that time. (See despatch No. 121, Legislative, 1851.)

It is somewhat difficult to arrange the Maori census returns for 1901 in the same way as they are given in the above tabulation. The results on page 21 of the "Census of Maori Population for 1901" are arranged by counties, and it is hardly possible to compare the districts at the two periods. However, by putting together a whole district like that to the north of Auckland, for the purpose of comparing the present population with the estimate made in 1842, it will be found that marked changes have taken place. Adding together the first four districts named in Mr. Hamlin's table, the estimated population in 1842 was 16,500 Maoris, whilst the census returns for 1901 for the whole of the peninsula to the north of the Eden County gave a population of 9,651. The Waikato and Manukau districts were estimated at 18,000 natives in 1842, but the entire district from Eden County to the Piako County contains to-day less than 6,000! The East Coast district, extending from Cape Runaway to Ahuriri (Napier), was undoubtedly the most populous portion of the North Island. The late Bishop of Waiapu, who first visited it in company with the late Rev. W. Colenso, F.R.S., expressed surprise at the large population to be found at Hicks' Bay, Waiapu, Poverty Bay, and Te Mahia, and Mr. Colenso, in a separate account that he gave of a second visit along the coast, said that Wikawitira, in the valley of the Waiapu, "is one of the largest native towns in New Zealand, containing, when all are assembled, from 3,000 to 4,000 souls." When he visited the place in 1838, with the late Bishop Williams, he says, "the inhabitants were living in the grossest darkness of heathenism. None knew how to read. Now nearly seven hundred persons assembled for service in the chapel of this village, a building which they had themselves built, measuring nearly 80 ft. by 40 ft., while in the school I had—First-class readers in the New Testament, 77; second-class readers who required prompting, 92; third class, 128; fourth class, rehearsers of catechisms, 240; and infants, 98: making a total at school, when numbers were in their plantations, of 635 persons, of whom more than 100 could read well."

Mr. Hamlin sets down the population of the whole East Coast (Nos. 19–20) at 30,120; and the census for last year

for the whole district from Cape Runaway to the Hutt, and including the Rangitikei, only amounts to 10,005, or to just one-third of what it was in 1842. These results suffice to show that the native population has markedly diminished since New Zealand became a British colony; and the diminution, such as is shown to have taken place in the most populous part of the Island, approximates closely to the average "falling-off" between Mr. Hamlin's estimate of 120,000 in 1842 and 43,101 in 1901.

But the reports of the census enumerators who were responsible for the native returns last year are in some respects reassuring. Judged alone by a comparison between the results of 1896 and 1901 the increase is certainly more than 8 per cent., whilst during the same period the increase of the colonists was 9·86 per cent. It is necessary to be careful, however, in accepting the facts of the native increase, although most capable men were appointed to collect the information. But it is for this very reason that extra caution is required. Thus, Mr. Gilbert Mair, chief enumerator for the Waikato and nine other counties, states, "The total population of the ten counties is shown to be 7,731, including 358 half-castes, whilst the number for the same counties in 1896 was only 6,661, an apparent increase of 1,070; but I very much doubt if there has been a real augmentation of numbers, and I attribute the increase more to the fact that my sub-enumerator visited every settlement and dwelling-place, which I am assured by the natives themselves was never before attempted." This statement exactly explains the position as to why such a marked apparent increase in population has taken place. The natives are now far more amenable to European regulations than they were a few years ago, and most of them do not object to give information which in previous years they were afraid to give, thinking that some bad result would be sure to follow. Thus, the enumerator for Taranaki and Patea points out that objections were raised by the native adherents of Tohu and Te Whiti, and "observations of querulous irritability were frequently made." Some wished to know whether the Government wanted to ascertain their numbers with a view to sending them against the Boers or otherwise deporting them. Many said, "Go thou to Tohu; if he signs we will sign." Inquiries as to the number of stock provoked bitter resentment. Here we have examples of the difficulties experienced by sub-enumerators when taking the census; and no doubt the difficulties were much greater in former years, hence it may be that the seeming increase in the native population is merely the outcome of more efficient means being employed by the sub-enumerators.

Mr. Hutchison, S.M., chief enumerator for Kaipara, Whangarei, &c., is convinced that the natives are rapidly diminishing in the north, for he says, "In some of the counties enumerated there appears to be an increase, in others of them a decrease, in the native population. But the increase in one does not set off the decrease in another, and upon the whole there is a positive falling-off in the numbers. Something of this result may perhaps have to be discounted, because many of the natives who employ themselves in gum-digging are of a migratory disposition, . . . but these cannot affect the conclusion that the native population, in these counties at all events, is a diminishing, and a rapidly diminishing, quantity."

The Rev. Mr. Bennett, native minister at Waitara, Taranaki, informed me that, in his opinion, the natives are not on the increase, and my own experience for more than twenty years along the East Coast leads me to the same conclusion.

No doubt there has been of late years an awakening in certain quarters of Maoridom. The young men from Te Aute College, the girls from the native schools at Hukarere, &c., are becoming in a measure alive to the dangers that threaten their race, and friends of the natives are not wanting to help on the "new growth" along European lines. The task is one of great difficulty owing to the opposing interests that exist; but to the credit of the General Government be it said that generous efforts have been made during the past few years, and since my former paper on the Maoris was written, to give to the natives the best advice in matters dealing with health and sanitation. Nor have the efforts been thrown away, if we may take the reports of the census enumerators as a guide. For example, Mr. E. C. Blomfield, S.M., in his admirable report on the northern district, tells us that he trusts the "*tohungas* are falling into disrepute with the Maoris"; that "drunkenness is undoubtedly decreasing"; that "no benefit was ever derived from the gumfields" by the natives; that "farming will undoubtedly be the future of the Maori"; that the Government should largely direct its attention to this aspect of training, and that "the social condition of the Maori requires more attention. Unfortunately, the women, not being trained to a satisfactory condition of domestic economy, gradually tire of the restraint of keeping a home clean, neat, and in pakeha style, and eventually find it so irksome as to warrant falling back into the free-and-easy style of living pursued by their forefathers"; and he closes with the statement that "more care and attention is required in the domestic education of the women."

On this latter point the enumerator of the Wairarapa district remarks, "If some native women or half-castes were

taught in the first principles of nursing they could soon instruct the others, and it would aid materially in the saving of life." The enumerator for the Waikato urges that "the inordinate use of tobacco, and, worse still, vile cigarettes and crude tobacco-leaf (*torori*), is really becoming a frightful curse, and must be checked if the race is to continue. It is not unusual to see mothers give infants their pipes to quieten them, and so strong a hold has smoking obtained that it is a deadly privation to keep a Maori from smoking for half an hour at a stretch." "I believe it would prove a great boon," continues the enumerator, "if a small pamphlet containing simple rules of sanitation were printed and widely circulated warning the natives of the dangers of inordinate use of tobacco, sleeping on the ground, and drinking Maori tea," &c.

Other quotations might be given to show how diverse are the conditions existing at present among the Maoris. There is, however, a consensus of opinion that crime, drunkenness, and even poverty are diminishing among them, and that they are coming to look upon European ways of living favourably, although, unfortunately, they do not always practise what they know to be best for their own well-being.

It is often urged by those who know but little of the ways of living among the Maoris that many of them are lazy, but this is a mistake. They are, indeed, industrious, but at present ambitionless, and as a rule they only toil to produce sufficient food for the year. Their surplus, whatever it may be other than sheep or cattle, is wasted; but this is the result of neglect, of ignorance, and of imperfect business knowledge. That considerable progress is being made by them is amply shown by the extent of their cultivations. In 1901 the acreage under crop owned by the natives was: Potatoes, 7,369; wheat, 3,724; maize, 4,943; other crops, 8,780; sown grasses, 78,628. Their sheep numbered 317,436; cattle, 36,943; and pigs, 57,642. The total number of sheep in the colony was 19,355,195; cattle, 1,256,680; and pigs, 250,975: in other words, the natives possess one in five of the pigs, one in thirty-four of the cattle, and one in sixty of the sheep; and in addition 1,793,880 acres of native land was held under lease by Europeans.

With such possessions it would be absurd to suppose the natives are a poverty-stricken people, for the income from the produce of their crops, &c., would amply suffice to sustain all of them in comfort; but there is a contra side to this apparent wealth. I do not know whether a return has ever been made of the indebtedness of the Maoris to storekeepers, hotelkeepers, general dealers, and others, but such a return would, no doubt, possess many interesting features. The thriftlessness of the Maoris is well known. "Sufficient unto

the day" is his motto, and, although many years have passed by since the natives first came in contact with the higher influences of civilisation such as were first represented by the missionaries, it is seldom one meets with members of the native race who display foresight like what is found among the colonists. There are those among them who fully realise the necessity of exercising foresight; but opposing interests, and the absence of emulation and of local government, all combine to produce an indifference even among the better educated and more ambitious young men, whilst the young women have no possible chance of improving under present social conditions.

The passing of the Maori Councils Act of 1900 is referred to by two of the enumerators, and possibly the granting of executive power to elective bodies may tend to improve the social status of the natives, and at the same time cause the disappearance of some of the weaknesses which beset the race and are carrying them down to certain ruin.

The home of the Maori in the "Land of the Great White Cloud" may, perhaps, be long continued, but it depends on the creation of activities, ambitions, and responsibilities, and the providing of ways for these qualities and attendants of progressive government to have full sway, as pointed out by me in a former paper. Let the improvements that have as yet taken place be balanced beside the losses and what do they show? The modern natives have acquired the habit of dressing in the fashions of the colonists, of eating similar food, and of living in similar houses. Many think that these are in themselves proofs of advancing civilisation. But the tinsel and the show and the thriftlessness, with the total absence of regard as to domestic responsibilities, are the bars to progressive growth, and unless internal government is introduced through which these aspects of social, and as a consequence political, progress can be guaranteed the Maori as an entity cannot continue in the land.

The Maori is the product of his special environment. The conditions that have operated through missionaries and whalers and colonists have undoubtedly produced a change in his ideals; but, unfortunately, he does not see along what lines he must go in order to bring about the realisation of his desires. Even the older natives are well aware that their children and grandchildren ought to be trained in the ways of the pakeha if they are to play their parts with any hope of success, and this desire manifests itself again and again wherever natives and colonists dwell near one another. The Maori Council is a step forward in the direction of progress, but the natives are scattered over a wide extent of country, and supervision can never become effective without

the recognised head man with some executive authority drawn from the Maori Council.

As the question of organization is the most pressing matter in the regeneration of the Maori race, I shall give here a summary of the proposals recommended by me six years ago.* These proposals were: (1.) The establishment of a system of internal local government. (2.) The opening of cottage hospitals for nursing the sick in various centres, where native girls could be trained in the art of nursing and healing, and, it should be added, cooking. (3.) An improved scheme of native education, so arranged that pupil-teachers and assistants might be selected from the native race for native schools. (4.) A system of scholarships for the specialisation of native studies adapted to native wants.

The first recommendation included all those measures that tend to the physical, social, and moral advancement of the people, such as (*a*) the regulation of buildings, (*b*) sanitation, (*c*) executive powers in case of epidemics or local forms of sickness, (*d*) regulation of stores, and (*e*) regulation of accommodation-houses and places of amusement. Attempts have lately been made to carry out the regeneration of the Maori by following along several of the lines indicated above; but there has also been introduced the plan of establishing a "special settlement" and starting technical schools. No one is more desirous than I am to see success crown the efforts of friends who would rescue a noble and intelligent race like the Maori, but technical schools on lines such as those shown in the Annual Report on the Native Schools are doomed to failure, for the simple reason that they fail in the initial step. Here are commenced among a people just emerging from barbarism, and from conditions altogether different from the twentieth-century civilisation, the system and the training such as are found in the most advanced kindergarten schools of commercial peoples to-day. In other words, a high type of modern utilitarian education is presented to a people whose minds have been moulded for generations along planes of objective training with nature as the great teacher, and who view things in a different way from what they are viewed by colonists and by the people at Home. Native children are imitative. They are copyists, and will imitate whatever is put before them, either in paper, plasticine, or paint; but is imitation to be the end of training? I take it that training is directive and suggestive. It aims to bring out characteristics of the individual. The bent of mind, the creative faculty, the application of one set of life phases to the regulation of conduct

* Trans. N.Z. Inst., vol. xxix., art. x., p. 150, *et seq.*

and action should all be brought to operate in the case of native children; and, whilst the effect of contact with a higher civilisation should be felt, it should only be manifested in the higher producing capacity of the natives along their own creative lines and concepts.

As for the "special settlements" for natives, the plan is simply the old "flour and sugar and blanket" system of the earlier history of the colonists. The natives have been spoilt by the insensible and ignorant method of destroying their self-reliance and independence. As a people they are powerful in government, but the loss of their recognised leaders and the hurry of reformers to make the "Maori a pakeha" has brought retrogression rather than progression among them. The Maori wants responsibility, and the moment he feels responsibility upon him there will be hope for his continuance as a living and progressive factor in the community. The Maori Council may be a means of doing good, but it has already been pointed out by many intelligent natives who are interested in land that the difficulties surrounding their interests are increased because they understood the plan of the Government, but now the "Councils" do as they please, and owners of "interests" are worse off than before, owing to their ignorance of the newer conditions. But the difficulties that appear at the outset of a scheme need not cause anxiety.

The functions of the Maori Council are important, and if rightly carried out will certainly tend to create a great interest in the internal affairs of native life and growth; but an important aspect yet remains neglected, and perhaps it is this that will affect, for better or for worse, the whole success of Maori regeneration. I refer to the home life as represented by the women. Suggestion has been made by me for the establishment of "cottage hospitals" in Maori districts. At small cost there could be provided in centres like Nuhaka, Tolago Bay, Tokomaru, Waipiro Matakawa, Waiapu, and other native centres "cottage hospitals," under the control of trained hospital nurses, assisted by the native girls drawn from a high-class native girls' school like Hukarere, in Napier. These hospitals might be made the very centre of a civilising influence such as cannot be introduced by any other means. Sympathy, kindness, home training, the healing of the sick, training in cleanliness and in cooking, could all be shown and illustrated, and the introduction of a humanising form of training such as could be carried out in the way suggested would bring the native women under the active influences of that form of living that is so much lacking among them to-day.

There is hardly a more pitiful sight than the Maori woman, ambitionless, homeless though not houseless, in-

different to opinion, to responsibility, to home. To gossip, to smoke, and while away the time in frivolous conversation, are common wherever native pas are to be found. When not on the cultivation, which she tends from sheer necessity, she is usually to be found smoking her pipe on the "village green," indifferent to home, and apparently without the ambition to have her surroundings improved. She has no home such as the colonist deems a necessity. A place to sleep, a place to cook, and a place to grow food or to gather shellfish, and you have the social environment of the Maori womanhood of the country, with a few rare exceptions. Contrast this with the training of the native girls at such a school as the Hukarere boarding-school for natives in the Town of Napier. There the girls are brought up under the higher influences of home life. They are trained to be clean and tidy and methodical. They have good beds to sleep in, healthy rooms to live in, and are provided with nourishing food at regular intervals. Neatness in dress, cleanliness in body and surroundings, and healthy living conditions are all brought to bear upon their training; but what do they find at home? How wide are the contrasts, and what little wonder it is that so many girls fall back into the old ways when they leave school to enter into life. Their home, they find, is as it was when they left it at the first. There are no sanitary arrangements, no water-supply, no regular meals, no privacy, nothing for their improvement, nothing to cheer, to attract, or to create hope and emulation. Nor is it possible for girls who know better and would be better to improve matters very much. A few days or weeks from school suffice to bring about the reaction. Hope is replaced by despair and indifference, for, after all, we are the creatures of our environment. And yet the natives are fond of tasty food; many of the women can cook to perfection in the *kopa Maori*, or native oven, but few of them know the value of milk, and eggs, and poultry, in providing suitable and nourishing food for the sick.

A short time since, when visiting up the East Coast, I went into a native village and found two young men suffering from pneumonia. Both of them were very sick. Each was lying on the ground with a small piece of *takapau* under him, and in a whare that was far from being waterproof. Their pale haggard faces betokened pain, and the hollow cough showed how rapidly their ailment was moving deathward. In reply to inquiries it appeared that the only food given to the patients was kumara and strong tea without milk, while hundreds of ducks, geese, and turkeys were running about in the pa, and eggs and milk were available in plenty. The common-sense and the experience of the nurse, however, were

wanting. This is only one illustration of scores that might be cited to show that it is the social, the domestic side of native life that should receive more attention if the race is to be preserved. Questions of land and of title, of technical schools, and of special native settlements, are insignificant compared with the social life of the natives, and those who would help in the regeneration of the Maori will need to begin at the home and with the womenkind, whose lot is so nearly associated with the perpetuation of the race. Homes have to be made and responsibilities realised, and these can be done by presenting, as in the case of the working-men's homes of the Old Land, higher ideals of domestic life, greater comfort, and more attractions. The women should know how to cook, to bake, to nurse the sick, and how to deal with child-life, and those things can be best done by the help of women who interest themselves in the uplifting of their kind to a higher and better plane of living.

The missionaries have had their day, and so have the land-seeking pakehas, and the result cannot be deemed as wholly satisfactory. As means to an end it is the women of New Zealand who can influence the social life of the Maori, and I would suggest to the Women's Council of New Zealand that the line of least resistance and of greatest promise in the uplifting of the people is among the native women. To establish a mission for the social regeneration of the women would prepare the native for conditions which the school life has made him ready to accept, but which he is unable to carry out himself. To bring the native women under the home influence, as represented by a school for plain cooking, nursing, and house management, should be the aim of those who have to do with the Native Councils, whose work must fail unless action is at once taken to influence the women in all that makes for healthy and happy homes, along lines such as the girls have learnt when drawn to such schools as those established at Hukarere and elsewhere.

As for the young men, I would again urge their claims to become the teachers, the ministers, doctors, and lawyers of their own people. There is no reason why a young and intelligent native should not receive an appointment as a pupil-teacher, an assistant, and finally as principal teacher in a native school. The natives are apt teachers. They can explain matters in a simple and interesting way, and should a training-school for the technical training of teachers be established in the North Island a proportionate number of young Te Aute students who are desirous of becoming teachers should be drafted into the school as a preparatory step.

In conclusion, I would point out what appear to me as serious omissions with respect to the Maori census. We give

the population—natives, half-castes, and so on—and each census shows a sudden change; sometimes there are a large number of half-castes; at other times there is a notable decrease. Yet no efforts, as far as I can gather, have ever been made to keep a record of births and deaths among the natives. This is now comparatively an easy matter, for the native schools and the half-educated native are to be met everywhere, and there would be no difficulty in keeping fairly correct records, just as is done in the case of the colonists. In the early days, when the missionaries dwelt in the land, the returns of births, marriages, baptisms, and deaths were carefully kept, and now that the breath of colonial advancement has been felt, even in the inmost recesses of the Urewera country, efforts should be made by the Government, acting through the Native Councils, to keep a record of all births, marriages, and deaths. When this takes place it will be seen that the period of childhood is a sad one among the Maoris. Thoughtlessness, want of proper food, and ignorance, are the three factors operating to-day among the Maori women, just as they operated in the early days of settlement; and, notwithstanding all the pretended sympathy that has been shown to them, no effort has ever been made to organize them and to bring them under regulations such as they must have if they are to continue as a people among us.

Organization is the only hope for continuance among an advancing community, and to destroy the organization of a people is to ensure their certain disappearance. This has been done in the case of the natives. Their methods of government have gone, for the chief is only so in name; and, although nominally there has been an increase in the native population, it undoubtedly arises from causes set forth in this paper. Unless means are adopted to help in the betterment of the women there can be no doubt as to the fate of the native race; but just as the Saxon women at the Conquest saved the language of their country and their identity as a people, so will the Maori women save their people if means are taken to train them in all those aspects of domestic and social life of which they are so sadly ignorant and without which progress is impossible.

ADDENDUM.

A summary of this paper was published by the *Hawke's Bay Herald* after it had been read, and Mr. Hindmarsh, sheep-farmer, of Tokomaru Bay, East Coast, forwarded to me a return of thirty married native couples whom he had known

since residing in that district. I give the return here as of much interest in its relation to the facts quoted by me from Mr. Hamlin's paper bearing upon the number of children born among the Maoris. The thirty married couples had a total of 113 children, of whom thirty-eight died and seventy-five are still alive. In one instance thirteen children were born, in two instances nine children, and in seven cases there was no issue. The following tabulation shows the results in each case:—

Children born.	Alive.	Dead.
6	4	2
13	4	9
9	7	2
1	1	0
6	5	1
5	5	0
6	4	2
2	1	1
5	3	2
2	1	1
6	4	2
7	0	7
0	0	0
8	5	3
1	1	0
4	3	1
0	0	0
0	0	0
2	1	1
2	1	1
9	8	1
7	7	0
0	0	0
3	3	0
2	1	1
2	2	0
0	0	0
0	0	0
0	0	0
5	4	1
113	75	38

ART. XIII.—*An Account of the Fiji Fire-walking Ceremony, or* Vilavilairevo, *with a Probable Explanation of the Mystery.*

By ROBERT FULTON., M.B., C.M., Edin.

[*Read before the Otago Institute, 23rd September, 1902.*]

Plates XVI.-XXI.

DURING the Coronation excursion to the Fiji Islands I had the rare opportunity of witnessing the ceremony of *vilavilairevo*, or fire-walking. To begin with, the term "fire-walking" is to my mind a misnomer, there not being any appearance in Fiji of walking upon fire. It would be more accurate to call it "heat-walking."

In the Christchurch *Weekly Press* of the 16th July, 1902, there appeared from the pen of Mr. W. Burke, Fellow of the Royal Photographic Society, an excellent account of the preparation of the oven and of the various stages of the heating of it, and with this account were some beautiful pictures of the fire-walkers from photographs taken on the spot by Mr. Burke(*a*). Some excellent photographs also appeared in the *New Zealand Graphic*(*b*) and in the *Auckland Weekly News*(*c*). Mr. Bourne, the artist who represented the last-named journal, very courteously sent me some fine copies, which I show herewith.

On the 30th June, 1902, we steamed down from Suva to Mbenga (Bega) in the Union Company's "Kia Ora," and when at some distance from the island descried smoke rising from a cocoanut grove, where we were told the "walking" would take place. On landing we could easily hear the crackling of the fire, and "all hands" at once proceeded to a spot where the natives could be seen collecting. When we approached the place the fire was glowing fiercely, and I could not without discomfort get to within 10 ft. of it, and even then had to step back at once. We were told that it had been burning for forty-eight hours, and that we had still about two hours to wait before the stones would be hot enough. We spent the time gathering ferns and inspecting huts, and on returning to the oven, or *lovo*, as it is called, found that the natives were preparing to open it up. This they did in the manner so graphically described by Mr. Burke, and also by Dr. Hocken in his paper (Trans. N.Z. Inst.)(*d*). We were fortunate in being able to view the whole proceedings from as little a distance as 20 ft. This was owing to the small

number of spectators, the day's outing having been arranged by the Union Steamship Company, through their courteous agent Mr. Duncan, for the "Waikare" passengers alone. The ship's company thus had the great advantage of standing round the fire at the above-mentioned distance, each person having, so to speak, a "front seat."

Mr. Burke thus describes the scene: "Now we make our way to the place prepared for the ceremony. A space about a chain in width had been cleared in a cocoanut grove. In the centre of this was an enormous fire made in a circular pit about 20 ft. across and 2 ft. in depth, the earth from the centre being piled up round the edges. When the hole is dug poles are placed radiating from the centre to the edges. Dry palm-fronds are placed under and upon these, then firewood of various sizes is stacked above. Finally the large stones are heaped on the top till the whole pile is several feet in height. The fire is lighted about forty-eight hours before the ceremony is timed to take place, and is kept fed with fresh supplies of wood. Eventually the whole mass glows with a white heat, and it is not comfortable to stand within a few feet of it; also, it is dangerous, as large splinters of stone fly far and wide. As the hour for the exhibition approaches groups of natives collect, some laden with green saplings about 20 ft. in length, others with supplejack-like vines. The fire is now sinking, and occasionally a large stone drops through. There is little smoke, and the stones fairly glow. Now the workers close in. The smaller vines are fastened in loops at the ends of the long poles or saplings. A loop is dropped over the end of a log not yet burnt out, several men man the sapling, and, with loud cries, the log is hauled away. This is repeated over and over again till no logs are left. The ends of the green saplings continually burst into flame, showing the intense heat in the oven. At last there seems to be nothing left in the pit but stones, some of which are shivered to pieces by the great heat; but the men are not yet satisfied. A large hawser-like vine now comes into use. This is thrown across the pit to one side, and round the ends of the saplings, which are forced into the glowing stones. Now willing hands pull on the vine, and the sticks are forced through the stones, turning them over and over and levelling them. Again and again this is done till the stones present a fairly even surface; but critical men, still unsatisfied, probe amongst the stones with the saplings and turn the smoothest side uppermost" (*a*).

There was no mistake about the heat. The stones were at first white hot. The logs and smoking chips were withdrawn in the clever manner so ably described above, the stones were levelled, and, what was not generally noticed,

owing to the distraction of attention by the "staging effects," had undoubtedly cooled. They had changed from white to red, and then to grey, and finally to black. This stirring-up process, yelling, heaving, hauling, &c., took over an hour, possibly nearer two, and was continued till every little piece of smoking wood was removed. Before the levelling I had rushed forward to within 5 ft. of the fire, and again after the levelling I tried the heat and found it diminishing; however, at the centre of the oven it must still have been very great.

At last, everything being ready, we were requested to keep perfect silence, as the fire-walkers were coming. There was no chanting or singing, or anything to suggest that it was in any way a religious ceremony. One of the performers first appeared alone, and, coming into the circle, Dr. Smith, of Dunedin, and myself were given an opportunity of making a scientific examination of him before the actual "walk" took place. He was a fine big fellow, about 5 ft. 9 in. in height, and was quite willing to be examined and overhauled. His pulse was a little over 90, his hands were cool, and his feet cold, most perceptibly colder than the rest of the body. There was no preparation to be detected on the feet, and they were perfectly clean and odourless. I did not test them by the sense of taste as I had the assurance of Dr. Hocken that there was nothing to be noticed in that somewhat heroic method of examination. The soles of the feet were yellowish-white, and perfectly smooth and pliable, like soft kid. The man wore a sulu of dry *Hibiscus* bark and *Canna* leaves, and small anklets of dry bracken, exactly the same as our *Pteris aquilina*. There were innumerable little black hairs on the legs, and these we closely examined. Having notified the director of ceremonies, Mr. Duncan, that we had finished our examination, he made a sign and the "walker" disappeared. Breathless with excitement, and in expectation of we knew not what, we awaited the arrival of the descendants of Tui Ngalita (Tui Qalita).

Now in dead silence on our part, but amid exclamations of astonishment from the onlooking natives, the mystic band of about a dozen men appeared from the depths of the cocoanut grove, and, passing through a little gap in our circle, walked deliberately across and twice around the heated stones. Looking back on it now it seems like a strange dream. Above and around us are the beautiful feathery fronds of the cocoanut and palm trees meeting overhead and almost shutting out the blue sky. Here a huge ivi-tree, with its lovely dark-green leaves and curiously buttressed stem, serves as a vantage from which half a score of black faces and frizzled heads peer down. From a tree on this side a great spider, with its 2 in. long tortoise-shell-coloured legs

and pure white marble-like body, sways in an almost imperceptible breeze; on the other side a kinematograph, busily clicking out its films, lays by a store of pictures for reproduction in far-distant lands; there on the heated stones that band of fantastically dressed magicians move across the kaleidoscope and are gone.

Quicker than I can write it the men had completed their "walk" and had passed into the gloom of the forest once more. To me they appeared to walk around the pit—that is, near the periphery; but I was assured by others that they really crossed the centre. However, there were so many things to watch that one was bound to miss something. Each man, as he walked, kept his eyes fixed upon the stones. One of the fire-walkers, as he came off the stones, was detained by Mr. Duncan, in order that we should again try and find out what we could in the interests of science. To begin with, the statement made by Dr. Hocken (Trans. N.Z. Inst., vol. xxxi.) as to the "scorching of the handkerchief," which, however, he had got second-hand, and did not himself confirm, must be taken "with a grain of salt."

It is possible that the earlier "fire-walkers" had different methods of procedure, but it is difficult to understand the "handkerchief story" of Lady Thurston(*h*) in the face of the following: The man came off the heated stones; there is no doubt of that. That he was the man we first examined we could not swear; they were all exactly alike to us, and came on and off so quickly that it would be perfectly easy for one man to be substituted for another, dressed as they were in the same kind of necklaces, sulus, anklets, &c. Now, whatever power the native may have to prevent his feet from scorching, there is nothing that I know of which will abolish the inflammability of dry bracken or dry fine wisps of ribbonwood bark; nor can one conceive of any reason why the short, black, crisp hairs on the legs should not show the least sign of scorching or burning if subjected to great heat, or to heat sufficient to scorch a handkerchief on the shoulder.

The man we examined after the "walk" had a pulse of 120; but this observation is not worth much, for the reason that we could not be sure that he was the man we had previously examined. I noticed the anxious, almost frightened, appearance on the countenances of some of the "walkers"—this fact was mentioned by Dr. Colquhoun, of Dunedin, on the occasion of Dr. Hocken's visit. If this was a second examination of the same man, the rise in pulse rate may be accounted for by the mental excitement and the intense surrounding heat. There was a distinct smell of cocoanut-oil on the bodies, but not on the hands, feet, or legs of the men. On feeling the soles of the feet of the man who came off they

seemed cool, if not cold, and on running the hand up the leg it was like putting it upon a person in high fever. The difference in temperature between sole and calf of leg was most marked, and must have been several degrees. Unfortunately, my thermometers were lost on the voyage from Dunedin to Auckland, and I could not make any accurate observation.

Immediately after the "walk" was over great bundles of loose *Dracæna* leaves were thrown on to the hot stones, and the performers, coming back, sat upon them for a few seconds in what was practically a fine steam-bath. The performance being finished, I went at once to the edge of the stones. The heat was not now unbearable, even on the outer rim of the oven. Here I moved some of the stones with my foot, and stood for a few seconds on one or two, which I found did not brown my boots, but which I had felt were too hot to handle. I asked one of the natives—or, rather, made signs to him—to get me a piece, and to my astonishment he coolly walked to the edge of the heap and started to move some of the hot stones with his bare feet for me. He was one of several men who had come down in the steamer from Suva with us, and was not one of the dressed-up "walkers" at all. This rather shook my faith in the "one tribe" theory, and made me form an idea, not yet removed from my mind, that any of the natives, on this or any other of the islands, can perform the feat if they choose; but they prefer, from a "theatrical point of view," that it remain the monopoly of the Nga Qalita Tribe.

I got a fine large piece of stone, about 10 in. by 5 in. by 2 in., raked out of the fire by this native. He had to drop it several times, as it was too hot to hold in the hand; but by means of sticks and cocoanut-leaf mid-rib he succeeded, and, wrapping it in a palm-leaf, I carried it to the sea-shore. Here it fizzled and steamed in the water for several minutes, and even then was too hot to carry in the naked hand. This specimen had been taken from near the centre of the oven, had been at the time of removal very hot, had been partially cooled by myself, and I was anxious to bring it back with me, but after carrying it all the way to the steamer "Waikare," many miles distant, I lost it going up the gangway ladder. I found it was slipping out of its palm-leaf basket, and, trying to catch it, felt it still unpleasantly hot, and had to drop it, unfortunately overboard.

Now as to an explanation of this so-called "mystery": It seems a pity in any way to detract from the interest of the Fiji excursions, or to do anything to lessen the popularity and enterprise of those responsible for these splendid exhibitions, but it is only right to dispel the idea that science can

offer no explanation of these "feats of magic." First, you will observe that the arrangement *for the heating of the stones* is peculiar. They are piled up on top of a heap of wood, and in this position subjected to an enormous heat poured into them from below and all around. If what is required be merely a surface of red-hot stones for walking upon, a much easier method would be to lay flat stones on the floor of the pit and then to light and maintain a huge fire on the top of them. That this is not what is wanted is most significant, and will be better understood later on. That the stones are still piled high on the burning logs and only "an occasional stone drops through" after forty-eight hours' burning, points to a possibility of some of the lower logs being absolutely green, otherwise it is hard to understand why the said logs have not been burnt up and the heap of stones collapsed long before forty-eight hours have passed.

As to the period of time occupied by the "walk," a great many observers—nearly sixty out of our two hundred spectators—had cameras, kinematographs, or kodaks, &c., and these people are quite accustomed to minute measurements of time, such as seconds and fractions of seconds. From several of the most expert of these I received the assurance that the time occupied by the "walk" was from fourteen to sixteen seconds, some said even less. In that space of time the performers took from twenty-five to thirty steps, consequently the sole of the foot was at no time in contact with hot stone for more than half a second.

The idea that the "walk" is made possible from long-continued use of the bare native foot to ground contact may be put on one side, as it was reported by Colonel Gudgeon that he on his own "bare and sensitive feet" walked over the hot stones and felt no burning, but only a sort of electric pricking(*i*). To this may be added the observations of Dr. Smith, Dr. Hocken, and myself, that the feet were soft and pliable, and not at all leathery or horny, though very possibly less sensitive than those of Europeans. That it is in the stones that we should look for an explanation is suggested by the fact that my boots were not browned by contact with them, although I stood on several for above a second each.

Another point not previously observed was the *coolness of the sole of the foot.* This was very well marked both before and after the "walk," and may have been due to the placing of the feet in cold water for a short time before the performance. It is possible that in the interior of the island very cold water may be obtainable. The islands all through the group are known to contain large caves, some of them with water at a comparatively low temperature(*e*). I mention this as it is difficult to account for the temperature of the feet,

which was particularly noticed by Dr. Smith and myself independently of one another, and then remarked upon, and confirmed by several trials with the hands on feet and legs.

It is a well-known fact that one can, with cold feet, bear for a long time—up to a minute in some instances—heat from a fire which for five seconds at ordinary foot-temperature would be insupportable. Provided that the heat is not enough to scorch the skin, there is every reason why in such a ceremony as the *vilavilairevo* a cold foot should have a great advantage over a foot at ordinary body-temperature. Cold seems to me the most likely adjuvant to the slow-conducting and slow-radiating nature of the stone, which is the main factor in this "jugglery." Of any local application like cocaine or alum there is no evidence whatever, and from Dr. Hocken's observations such seems impossible.

Next, as to the stones which are heated and walked upon when hot. They appear to be of a dense black basalt, many of them round in shape, and before heating have somewhat of the look of Moeraki boulders. During the heating process they explode, probably from water expansion, and small fragments fly about. "All rocks that have once been in a fluid or semi-pasty condition contain water within their component crystals. This is not water that has been subsequently introduced, but is contained in minute cells. In the solid crystals of lava, which were erupted recently or in early geological periods, the presence of water in minute cavities may be readily detected. It is a fact that all rocks contain 'interstitial' water, which is not combined with their mineral constituents, but merely retained in their pores" (*m*).

We were told that the natives would not allow us to "get a hold" of the real stone at all, but would "palm off" on us another sort altogether. This statement was incorrect. We were allowed to take any or as many of the stones as we liked, and there was no attempt on the part of the "walkers" or the "supernumeraries" to prevent our making the most minute investigation into all points likely to throw light on the subject. There did not seem to be any of the stones lying about; in fact, I made careful search for the same kind of stone on the shore and beach at Mbenga (Bega), and, finding none, concluded that they had been brought from inland, probably from near some extinct volcanic crater. This seems likely, as many observers consider the stone of the nature of basalt, some term it "volcanic," some "hard conglomerate." Not being able to give any opinion on this point myself, I submitted a small fragment I had to Dr. Marshall, of the Otago School of Mines, and received the following report:—

University of Otago, School of Mines, 14th August, 1902.

Rock for Determination.

Dr. Marshall has examined this rock microscopically, and finds it is an augite andesite of the ordinary type, compact and splintery in fracture. It consists of an aggregate of plagioclase augite and a little hornblende set in a fine-grained groundmass of feldspar microlites. Augite andesite is a common rock in the Auckland Goldfields and in the central volcanic region of the North Island, while many kinds of andesite are found around Dunedin. James Park, Director.

It is acknowledged that the stones are of one particular kind, and that the Mbenga (Bega) performers carry them from island to island, and will not walk on any other kind. That is a fact, and points away from the idea held by most people that the mystery is in the "walkers" and not in the "walked upon." I have no doubt that near some of the old craters of Viti Levu, or the other islands of the group, the same stone can be found in abundance.

What struck me at once on handling the stone, or rather trying to do so, was its extraordinary tenacity of heat, or, in other words, the extremely slow throwing-off of its heat by cooling or radiation. Even after frequent, and often continuous, dippings in cold sea-water, and water from a fresh stream that ran out at that spot, the stone seemed little or no cooler. That stones were carried for more than two hours after these dippings and still remained uncomfortably warm gives one a clue to the mystery.

This stone takes two days to get to its proper condition, for the natives keep the furnace going and refuse to walk unless that time has elapsed; and when the ceremony is over it takes a corresponding time to cool, for yams, taro, &c., wrapped in leaves take, they say, two days' cooking before being in a fit state for eating. Now, Darwin describes the Tahitian method of cooking as follows: "They made a small fire of sticks and placed a score of stones of about the size of cricket-balls on the burning wood. In about ten minutes the sticks were consumed and the stones hot. They had previously folded up in small parcels of leaves pieces of beef, fish, ripe and unripe bananas, and the tops of the wild arum. These green parcels were laid in a layer between two layers of the hot stones, and the whole then covered up with earth so that no smoke or steam could escape. In about a quarter of an hour the whole was most deliciously cooked" (*l*). The articles of food which we saw placed in the *lovo* after the "fire-walk" were almost precisely the same as those here mentioned, yet owing to the slow giving-off of heat from this particular stone the cooking was greatly prolonged.

That vegetables which can be cooked in an ordinary house-oven in three or four hours should remain in the *lovo* for forty-eight and not be burnt to cinders or steamed

to pulp again points to but one conclusion. It seems to me evident that such a stone does not throw off or radiate its heat to anything like the extent that an ordinary stone does, and that, given a foot in contact with it for one second, the heat penetrating into that foot is not more than a fraction of what would come from a stone of different composition in the same space of time. I draw the conclusion that this volcanic stone does not burn matter coming momentarily in contact with it to the extent that many other heated bodies would. Further, it is a remarkable fact, which seems to have hitherto escaped notice, that fresh stones are used for each performance. Fresh boulders in heaps certainly appear in all pictures of preparation for "fire-walking," and the description of the heating is in all cases almost identical. So far as I could gather that is so, the natives never using split or already burnt stones, but having fresh ones for each "walk."

Now, it was noticed by Mr. Burke and others(*j*), including myself, that the assistants, or "supers," as one may call them, were most particular in turning and re-turning the stones until in most cases the smooth side—that is to say, the flattened side—was uppermost. To me the significance of that arrangement was evident. The stones, originally rounded, were split by the action of the heat into segments, in many cases preserving on one side a convex surface, which I think received more of the heat, being part of the *original outside* of the stone; the flattened or fractured surface, on the other hand, being from the inside, received, owing to poor conduction, a less amount of heat. It would be possible for the "walkers" to avoid any stone which did not show a flattened or fractured surface, and that choice, I think, would lessen the amount of heat absorbed into the foot. This seems to me a point for future observers to look into.

Fresh round stones are used every time, and the "walking" does not take place till all or nearly all of them are split up. The fire is then removed, and much time and trouble is spent in getting the flattish surface of the stone upwards. It must be borne in mind that while the stones are lying in the oven the upper surface of each is practically the only part that is cooling, and that to a very slight extent, as the lower and greatly heated surfaces are then all in contact with one another. This it is that makes the "mean" heat of the stone seem so great on removal from the fire, and the comparative coolness of one surface is unsuspected. So long as the stone remains in the highly heated *lovo* radiation is infinitesimal, first from the peculiar character of the stone, of which you shall presently hear, but also from the fact that

the general atmosphere in and around the pit is so high in temperature. The moment the stone is removed from the oven to a cooler surrounding atmosphere radiation begins to take place more rapidly—that is, the stone burns more easily a hand or foot in contact with it.

It is a well-known fact that all these volcanic rocks are bad conductors of heat, and numerous observers have commented upon this. Those who have visited volcanic regions tell us "that the hardened crust of a lava-stream is a bad conductor of heat, consequently when the surface of the mass has become cool enough to be walked upon the red-hot mass may be observed through the rents to lie only a few inches below. Many years, therefore, may elapse before the temperature of the whole mass has fallen to that of the surrounding soil. Eleven months after the eruption of Etna, Spallanzani could see that the lava was red hot at the bottom of the fissures, and a stick thrust into one of them instantly took fire. The Vesuvian lava of 1785 was found by Breislak, seven years afterwards, to be still hot and steaming internally, though lichens had already taken root on its surface. The ropy lava erupted by Vesuvius in 1858, and spread over the surrounding country, was observed in 1870 to be still so hot even near its termination that steam issued abundantly from its rents, many of which were too hot to allow the hand to be held in them. Hoffmann records that the lava that flowed from Etna in 1787 was still steaming in 1830. But still more remarkable is the case of Jorullo, in Mexico, which poured out its lava in 1759. Twenty-one years later a cigar could still be lighted at its fissures; after forty-four years it was still visibly steaming; and even in 1846—that is, after eighty-seven years of cooling—two vapour columns were still rising from it" (*n*). These stones, therefore, being of igneous origin, are almost certainly very slow in conductivity and also in radiation or cooling, but for actual proof of this one must go further.

In order to prove, if possible, my theory that this stone does not throw out as much heat, or, in other words, does not burn so severely, as an ordinary stone of different composition, I have had some experiments conducted at the Otago School of Mines by the Director, Professor Park. I asked him to compare in some way the heat-throwing-off property of this stone with that of others of very different composition, by subjecting them for the same space of time to the same amount of heat and then measuring the respective amounts of heat radiated. I suggested various rough experiments, such as heating the stones from below and having on the upper surface evaporating glasses of water or highly inflammable liquids, &c., in order to prove which

stone takes the greatest length of time to conduct from the under to the upper surface enough heat to cause evaporation or ignition, &c. Professor Park says,—

I have made a series of experiments to determine conductivity and rate of radiation, as requested by you, and the results are appended herewith. To make comparative tests with skin or feathers would be difficult.

Augite Andesite for Determination of Conductivity and Rate of Radiation of Heat.

Conductivity.—To determine the relative thermal conductivity of the andesite a pencil of it was tested simultaneously with pencils of copper, slate, and rhyolite, each pencil being 8 cm. long and 0·5 cm. in diameter. Taking the thermal conductivity of copper as equal to 1,000, the relative conductivity of the others was found to be as follows: Slate, 7·63; andesite, 6·67; rhyolite, 2·35. From these figures it will be seen that the highly acidic rhyolite is practically a non-conductor of heat, while the conductivity of the others is very feeble.

Radiation of Heat.—A series of experiments was made to determine the relative rate of radiation of marble, rhyolite, andesite, basalt, and cast iron. For this purpose a portion of each weighing 10 gm. (150 gr.) was heated in a muffle furnace to a temperature of about 850° C. (about 1,562° F.) and then plunged for one second of time into a glass beaker containing 100 c.c. of water. The portions of material were shaped so as to give approximately an equal surface of radiation in each. The number of degrees of temperature through which the water was raised was carefully noted. In most cases the experiments were repeated three times, and in all cases twice. The "means" of the different readings were taken, and, expressing the radiation of iron as 100, it was found that the relative rate of radiation of the others was as follows: Marble, 52; rhyolite, 50; andesite, 48; basalt, 45.

The experiments took many hours and the making of apparatus for the tests. They seem to bear out your contention *re* feeble radiation of the andesite—that is, the temperature might be very high, but, the rate of radiation being so low, the heat given off in one second of time would not be sufficient to burn the feet.

From what I have said, and from Professor Park's experiments, the results of which I have given, with his remarks thereon, it seems to me that the fractured or inside surface of this stone does not, owing to slow conductivity, receive nearly the amount of heat one would expect. Secondly, owing to the slow radiation of heat, also proved by these experiments, the foot is not burnt when coming into contact with the stone for a second or less. It would be interesting to have some of the unsplit stones brought from Mbenga (Bega) to Otago and heated to a temperature that would cause splitting and then have the radiation from the two surfaces tested in some way. This testing is hardly possible of application on the site of the performance at Fiji, but would have to be carried out in a properly equipped laboratory, as at the Otago School of Mines.

My thanks are due to Dr. Marshall for his report on the character of the stone, and I am much indebted to Professor Park for the interest and trouble he took in the matter, and for his kindness in devising and performing the tests, which

have brought out the points I emphasized, and of which I required scientific proof. It is another instance of the advantage of having in our midst an institution such as the Otago School of Mines, where one can have scientific investigations accurately carried out at a few hours' notice.

Since writing the above I have read an article in *Nature* on the Tahiti "Fire-walk," by Professor S. P. Langley, of the Smithsonian Institution, Washington. In his account the shape of the *lovo* is more oblong than circular, and makes it possible for a straight march from the one end to the other and back again. Professor Langley states that before the ceremony he had been told that he could, without fear of burning, "walk" in leather boots or shoes, and he was a witness of this performance, one of his companions walking, and even standing still, on the hot stones for eight or ten seconds "before he felt the heat through his thin shoes." Many others also walked over the stones in their boots without any sign of scorching(*f*).

In the Tahitian account the fire only took four hours to prepare, whereas we were assured that it always takes two days in Fiji. There was in our case none of the flame darting up during the "walking," as described by Professor Langley, and there was practically no smoke. The flames and white-hot stones, the burning poles, the yelling and shouting while the stones were being levelled, were all part of the "staging of the piece," and were strung out to draw away the attention from the fact that time was passing and the stones slowly cooling.

Professor Langley went to great pains to form a scientific estimate of the actual heat of the stone, and, though he had many difficulties in the way, made it clear that the mean heat of a large piece which he had seen walked upon, and which he had himself cooled, was at the "time of removal from the fire about 1,200° F., but that the walked-upon surface was almost certainly indefinitely lower."

In Professor Park's letter to me enclosing the report he says, "The radiation tests show that marble parts with its heat more rapidly than either andesite or basalt, hence would burn when andesite would not." This is very interesting, as Professor Langley reported that the head performer who took part on that occasion had failed when he tried on a neighbouring island with "stones of a marble-like quality." He was also asked to put his foot between the hot stones into the flames below, or on to the lower red-hot stones, but he very cleverly declined in a most dignified manner with the words, "My fathers did not tell me to do it that way." He also promised to hold a piece of the hot stone in his hand, but, as Professor Langley says, "he did not do so."

A portion of the stone was examined at Washington, and was described by Professor Langley as follows: "It was a volcanic stone, and on minute examination proved to be a vesicular basalt, the most distinctive feature of which was its extreme porosity and non-conductibility, for it was subsequently found that it could have been heated red hot at one end while remaining comparatively cool at the top. Its conductibility was so extremely small that one end of a fragment could be held in the hand while the other end was heated indefinitely in the flame of a blow-pipe."

Mr. R. M. Laing, M.A., B.Sc., in an article in the Christchurch *Weekly Press* of the 16th July, gives a brief account of the "fire-walk" as witnessed by various persons in different countries, and criticizes Professor Langley's report adversely. He describes the Professor's experiment to determine the heat of the stone, and then goes on to draw conclusions, which Professor Langley was most particular to refrain from doing. All that Professor Langley said was that the mean heat of the stone which he had seen walked upon was, "at the time of removal from the oven, about 1,200° F., but that the walked-upon surface was almost certainly indefinitely lower." He stated that the stone was a very poor conductor of heat, and gave its specific heat and its specific gravity. He advanced no theory, but confined himself to facts as seen in the laboratory. He made no endeavour to show how one surface might be colder than another in the *lovo*. Mr. Laing, however, proceeds thus: "Professor Langley's argument is this: It is quite true that the under-surface of the stone was at a very high temperature, but, being a piece of vesicular basalt, it was a very bad conductor of heat, and consequently its upper surface must have been indefinitely lower in temperature, and therefore low enough to enable the native sole to rest momentarily in contact with it and not be burnt. Now, there is a specious appearance of scientific exactitude about this 'argument' very apt to mislead the unwary. . . . It at once enables the reader to point out the defects of his 'argument.' It depends entirely upon the assumption that the upper surface of the stone is comparatively cold, and that the contact with it is only instantaneous." Mr. Laing then says, "*It is quite true that in this case, as in so many others, appearances may be deceptive, and that the upper surface of the stones may not always be at a red heat, and may, indeed, in some cases be comparatively cool*" (*k*). That is exactly what Professor Langley did his best to find out, and what in this paper I have endeavoured to prove, and Mr. Laing's use of that paragraph destroys, to my mind, the whole of his criticism. Professor Langley made use of no such terms as "upper

surface" and "under-surface," but used the words "walked-upon surface," and mentioned no part of the stone as having been specially heated in the oven. He merely referred to the physical characters of the stone, and left any conclusions to be drawn by others.

Mr. Laing says that Professor Langley's argument "will not explain the case in which men walk on burning embers, and not on red-hot stones," such as the performance in Mauritius, where Hindu coolies walk on red-hot coals. From a description of the "fire-walk" in Tahiti, where Professor Langley made a careful examination of the main factor, a heated stone, to argue that he did not show how in Mauritius, 8,000 miles away, men can walk upon red-hot embers, seems to me peculiar. Professor Langley reported on the Tahiti "walk" on heated stones, which he had himself witnessed; not on the Mauritius "walk" on red-hot coals, which he had never seen. Until one of the performances in Mauritius, Japan, or elsewhere, has been witnessed and reported upon in a strictly judicial manner by a scientist of authority, one cannot accept the statement that the men walk upon red-hot coals. The performance, as seen in Fiji, is so different from the conception previously formed from newspaper accounts, that it is more than likely that much exaggeration will be found in the descriptions of the "walking" in other parts of the world.

The thanks of the scientific world are certainly due to Professor Langley for calling attention to the peculiar character of the Tahiti stone, and for estimating the mean heat of a piece which he had seen walked upon; but he did not show in what way the poor conductivity might be utilised, nor did he allude to the more important fact of slow radiation.

In conclusion, I repeat that the main factors in this strange apparent immunity from burning at Mbenga (Bega) are as follows:—

(1.) The slow radiation of heat from these basaltic stones.

(2.) The stones are gradually heated until split by the expansion of the water therein, the fire is then put out, and the stones are carefully arranged fractured surface upwards.

(3.) Owing to poor conduction, the inside of the stone, or fractured surface, is not nearly so hot as the spectators imagine.

(4.) The general heat of the *lovo* is so great that radiation from each individual piece of stone is infinitesimal, and much less than it is when the stone is removed from the oven to a cooler surrounding atmosphere.

(5.) The foot is only momentarily in contact with the heated stone.

(6.) The foot is naturally cold or artificially cooled.

These are, I think, the reasons for the facility with which the magicians perform their "fire-walk," and I must say that it is a smart piece of jugglery or "savage magic," and not by any means an inexplicable mystery.

REFERENCES.

(*a.*) Christchurch *Press*, 16th July, 1902.
(*b.*) *New Zealand Graphic*, 10th July, 1902.
(*c.*) *Auckland Weekly News*, 17th July, 1902.
(*d.*) Trans. N.Z. Inst., vol. xxxi., p. 667.
(*e.*) "Camping among Cannibals," by Alfred St. Hill Johnston. Macmillans; 1886.
(*f.*) *Nature*, 22nd August, 1901.
(*g.*) *New Zealand Graphic*, 10th July, 1902, p. 106.
(*h.*) "Journal of the Polynesian Society," vols. ii. and iii.
(*i.*) "Journal of the Polynesian Society," vol. ii.
(*j.*) Christchurch *Press*, 16th July, 1902, p. 6.
(*k.*) *Ibid.*, p. 55.
(*l.*) "Naturalists' Voyage round the World," Darwin, p. 491.
(*m.*) Encycl. Britt., vol. x., pp. 260 and 262.
(*n.*) *Ibid.*, p. 248.

ART. XIV.—*The Adjustment of Triangulation by Least Squares.*

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IT is proposed in the following paper to select examples of the ordinary methods of adjusting triangulation as practised in New Zealand and to apply to them the least-square adjustment, so as to compare the relative results obtained, and to show by actual examples that this method of adjustment alters the observed angles less than any other method. It will also be shown that the least-square adjustment can be simply and readily applied to most cases that occur in practice.

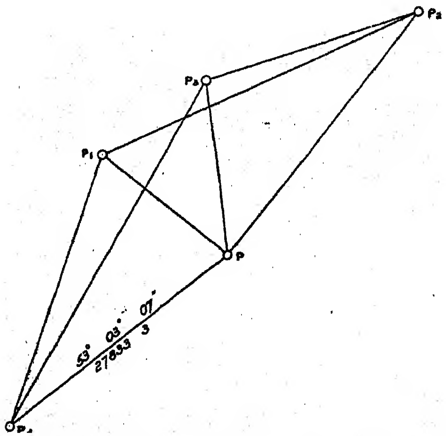
It is hoped that this treatment of the subject will be of use to the practical computer, and that it will enable him to see the advantages of the least-square adjustment by comparing its results with those usually obtained.

To make the treatment as simple as possible it will be assumed that all the angles are equally well observed.

Example No. 1.—The Adjustment of Four Plane Triangles.

For the purposes of comparison with the usual method of adjusting triangulation (in which one-third of the triangular error is applied to each angle of the triangle) an easy example is selected embracing the adjustment of four plane triangles.

The side P_4 P in the figure is a side of the existing triangulation, and is to be adopted as correct both in bearing and length. From this side it is desired to extend the triangulation so as to include the points P_1 P_3 and P_2. The angles are all observed, and are shown in column No. 2 of the schedule. No observation was possible between P_1 and P_3.



I. *Adjustment as Four Separate Triangles.*

The angles in each triangle are adjusted by applying to each angle one-third of the triangular error of the triangle.

The adjustment is shown in the schedule in columns 1 to 4.

In column 1 the names of the angles are entered as follows (see figure) :—

$$A_1 = P\ P_1\ P_4 \qquad A_2 = P\ P_2\ P_1$$
$$B_1 = P_1\ P_4\ P \qquad B_2 = P_2\ P_1\ P$$
$$C_1 = P_4\ P\ P_1 \qquad C_2 = P_1\ P\ P_2$$

$$A_3 = P\ P_3\ P_2 \qquad A_4 = P\ P_4\ P_3$$
$$B_3 = P_3\ P_2\ P \qquad B_4 = P_4\ P_3\ P$$
$$C_3 = P_2\ P\ P_3 \qquad C_4 = P_3\ P\ P_4$$

Column No. 2 contains the observed angles.

In column No. 3 one-third of the triangular error of each triangle is applied to each angle.

Column No. 4 gives the sums of the angles (seconds only) of columns Nos. 2 and 3.

With these angles (from column 4) the triangles are calculated, and the following results are obtained:—

First Pair of Triangles—P_1 P_4 P and P_2 P_1 P.

Side.	Bearing.	Distance. Links.	Remarks.
P P_4	53° 03′ 07″	27833·3	Adopted as base.
P_4 P_1	20° 13′ 46·3″	29069·9	
P_1 P	130° 51′ 38·7″	16120·5	
P_1 P_2	67° 42′ 42·7″	34843·4	
P_2 P	220° 09′ 19·7″	31089·0	

Second Pair of Triangles—P_3 P_2 P and P_4 P_3 P.

Side.	Bearing.	Distance. Links.	Remarks.
P P_4	53° 03′ 07″	27833·3	Adopted as base.
P_4 P_3	30° 49′ 18·7″	40207·6	
P_3 P	174° 43′ 37·3″	17874·2	
P_3 P_2	74° 37′ 29·0″	22499·4	
P_2 P	220° 09′ 24·7″	31093·3	

Comparing the bearing and length of the side P_2 P as obtained from the two sets of triangles, we have—

220° 09′ 19·7″ 31089·0 links ; and
220° 09′ 24·7″ 31093·3 „

giving differences of 5″ and 4·3 links.

The application of the ordinary adjustment, resulting as it does in these differences, is therefore very unsatisfactory, and the question arises as to whether it is desirable in this and in similar cases to adopt some further adjustment to the observed angles so as to eliminate the discrepancies shown above.

Before discussing the further adjustment it may be as well to remark that the ordinary procedure would be to adopt the mean values of the bearing and distance of P P_2. None of the other sides, however, would receive any correction; consequently if the calculation is repeated, using the mean value of P P_2 as base, an entirely different set of values will be obtained for all the other sides of the triangles.

As the need for further adjustment is obvious, the method of applying it will now be indicated.

II. *The Least-square Adjustment.*

The problem to be solved is: Given the observed angles of the four triangles, corrected as shown in I., by applying one-third of the error of each triangle to each angle, what further corrections must be made to these angles so as to eliminate the discrepancies found above?

It is evidently desirable that the corrections should be as small as possible so that no undue alterations are made to the angles: this condition is satisfied when the sum of the squares of the corrections is a minimum.

The application of this condition is shown on the schedule, and is briefly as follows:—

In column No. 5 the natural sines of the angles in column No. 4 are given.

If the sines in No. 5 were correct we should have—

$$\frac{\text{Sin } A_1 \sin A_2 \sin A_3 \sin A_4}{\text{Sin } B_1 \sin B_2 \sin B_3 \sin B_4} = 1.$$

This equation shows that the length of P P_2 calculated from P P_4 by the first pair of triangles should be the same as the length calculated by the second pair of triangles.

This is not usually the case, so put

$$\frac{\text{Sin } A_1 \sin A_2 \sin A_3 \sin A_4}{\text{Sin } B_1 \sin B_2 \sin B_3 \sin B_4} = 1 + \epsilon,$$

where the sines are taken from column No 5 and ϵ is n radians.

To convert ϵ into seconds multiply the value in radians by 206265 (= number of seconds in 1 radian).

The calculation is shown on the schedule, giving, in this particular example, $\epsilon = + 28''{\cdot}01$.

(NOTE.—Attention must be paid to the sign of ϵ.)

The other necessary condition is that the sum of the angles C_1 and C_2 should equal the sum of the angles of C_3 and C_4, or—

$$C_1 + C_2 = C_3 + C_4.$$

This is not usually the case, so put

$$C_1 + C_2 = C_3 + C_4 + \epsilon_0,$$

where the angles are taken from column No. 4 and ϵ_0 is in seconds. This gives $\epsilon_0 = -5''$ in this example (see schedule).

(NOTE.—Attention must be paid to the sign of ϵ_0.)

In column No. 6 the natural cotangents of the angles are inserted.

In column No. 7 twice the cotangents are entered.

$$\text{Let } \alpha_1 = \cot A_1 \qquad \alpha_2 = \cot A_2$$
$$\text{,, } \beta_1 = \cot B_1 \qquad \beta_2 = \cot B_2$$

and similarly for the other angles.

$$\text{Let } a_1 = 2\alpha_1 + \beta_1 \qquad a_2 = 2\alpha_2 + \beta_2$$
$$\text{,, } b_1 = -\alpha_1 - 2\beta_1 \qquad b_2 = -\alpha_2 - 2\beta_2$$
$$\text{,, } c_1 = -\alpha_1 + \beta_1 \qquad c_2 = -\alpha_2 + \beta_2$$

and similarly for a_3, b_3, c_3: a_4, b_4, c_4.

In column No. 8 the values of a_1, b_1, c_1, &c., are given, and a check is obtained by noting that $a_1 + b_1 + c_1 = o$.

Square all the values in column No. 8 and add them. This

is done readily on the Brunsviga calculating-machine without any intermediate record, the result in this example being—

$$\Sigma\,(a^2 + b^2 + c^2) = +\,126{\cdot}790.$$

Let $k = \frac{1}{6}\,\Sigma\,(a^2 + b^2 + c^2)$

" $h = c_1 + c_2 - c_3 - c_4$ (from column No. 8).

" $i =$ the number of triangles.

Next form the following equations :—

$$hP + 2iQ + \epsilon_0 = o$$
$$2kP + hQ + \epsilon = o$$

and solve them for P and Q.

With these values of P and Q calculate the corrections to the observed angles thus—

$$\begin{array}{ll} x_1 = a_1P - Q & x_2 = a_2P - Q \\ y_1 = b_1P - Q & y_2 = b_2P - Q \\ z_1 = c_1P + 2Q & z_2 = c_2P + 2Q \end{array}$$

$$\begin{array}{ll} x_3 = a_3P + Q & x_4 = a_4P + Q \\ y_3 = b_3P + Q & y_4 = b_4P + Q \\ z_3 = c_3P - 2Q & z_4 = c_4P - 2Q \end{array}$$

where x_1, y_1, z_1, &c., are the corrections in seconds, and the corrected angles are—

$$\begin{array}{llll} A_1 + x_1 & A_2 + x_2 & A_3 + x_3 & A_4 + x_4 \\ B_1 + y_1 & B_2 + y_2 & B_3 + y_3 & B_4 + y_4 \\ C_1 + z_1 & C_2 + z_2 & C_3 + z_3 & C_4 + z_4 \end{array}$$

where the angles A_1, B_1, &c., are taken from column No. 4.

Columns 9, 10, and 11 show the calculation of the corrections.

Column No. 12 gives the final angles (seconds only), and is equal to column 4 + column 11.

Column No. 13 gives the natural sines of the angles in Column No. 12.

This completes the calculation of the least-square corrections.

In practice it is always desirable to check the results obtained, consequently the two following checks are applied :—

(α.) By forming the products of—

Sin A_1 sin A_2 sin A_3 sin A_4 (from column 13) ; and
Sin B_1 sin B_2 sin B_3 sin B_4 "

which are equal (see schedule).

(β.) By comparing the values of—

$C_1 + C_2$ (from column 12) ; and
$C_3 + C_4$ "

which are equal.

The triangles are now solved, using the angles from column 12, and the results are—

First Pair of Triangles.

Side.	Bearing.	Distance.	Differences. Bearing.	Differences. Distance.
		Links.		Links.
P P_4	53° 03′ 07″	27833·3	...	...
P_4 P_1	20° 13′ 44·6″	29070·1	+ 1·7″	− 0·2
P_1 P	130° 51′ 39·0″	16120·8	− 0·3″	− 0·3
P_1 P_2	67° 42′ 41·7″	34845·1	+ 1·0″	− 1·7
P_2 P	220° 09′ 22·1″	31090·6	− 2·4″	− 1·6

Second Pair of Triangles.

Side.	Bearing.	Distance.	Differences. Bearing.	Differences. Distance.
		Links.		Links.
P P_4	53° 03′ 07″	27833·3	...	...
P_4 P_3	30° 49′ 22·2″	40206·6	− 3·5″	+ 1·0
P_3 P	174° 43′ 36·9″	17873·0	+ 0·4″	+ 1·2
P_3 P_2	74° 37′ 28·7″	22497·3	+ 0·3″	+ 2·1
P_2 P	40° 09′ 22·1″	31090·6	+ 2·6″	+ 2·7

The columns headed "Differences" give the differences between the least-square values and the values obained in I.

A comparison of the values of P_2 P as calculated from each pair of triangles shows that the bearing and distance agree exactly.

The process of adjustment here described completely satisfies the geometrical conditions of the figure, and it does so by making the sums of the corrections the least possible.

For the theory of the adjustment reference must be made to any of the treatises on least squares. See in particular "Geodesy," by Colonel A. R. Clarke, C.B., Oxford, 1880, pp. 217–225. The method here outlined differs from that given in Clarke, inasmuch as the triangular error is applied before the condition equations are derived, thus lightening the subsequent work very considerably, and thereby lessening the risk of numerical slips.

This method also permits of comparison between the ordinary triangular adjustment and the least-square adjustment, as will be seen by comparing columns 3 and 11, where column 11 shows the additional corrections necessary to satisfy the geometrical conditions of the figure.

In this example the calculation has been carried to two decimal places of a second, not because the observations justify so much refinement, but to avoid an unequal distribution of the errors, as, for instance, would occur in distributing an error of 2″ among three angles. If this is done to the nearest second, then two angles would receive a correction of one second each and the third angle would remain unaltered. This would not have been consistent with the theory of the adjustment, which provides that exactly one-third of the triangular error must be applied to each angle.

The whole of the calculations have been done on the Brunsviga calculating-machine with ease, rapidity, and certainty.

SCHEDULE

(1.) Angles.	(2.) Observed Angles.	(3.) Correction - ⅓ Error of A.	(4) =(2)+(3). Corrected Angles.	(5) = Sines of (4). Sines of Corrected Angles.	(6.) Cot. of (2).	(7.) Twice Cot of (2).	(8.) a, b, c.	(9) =(8)×P.	(10.) Q and 2 Q.	(11) =(9)+(10). Least-square Corrections to Angles.	(12) =(4)+(11) Final Angles.	(13.) Sines of (12).
	° ′ ″	″	″					″	″	″	″	
A_1	69 22 7	+0·67	7·67	0·9358678	α_1 = +0·376	+0·752	a_1 = +2·302	−1·501	−0·560	x_1 = −2·061	5·61	0·9358643
B_1	32 49 20	+0·66	20·66	0·5420369	β_1 = +1·550	+3·100	b_1 = −3·476.	+2·266	−0·560	y_1 = +1·706	22·37	0·5420438
C_1	77 48 31	+0·67	31·67	0·9774483	..	..	c_1 = +1·174	−0·765	+1·120	z_1 = +0·355	32·02	0·9774487
	179 59 58											
A_2	27 33 24	−1·00	23·00	0·4626214	α_2 = +1·916	+3·832	a_2 = +4·338	−2·828	−0·560	x_2 = −3·388	19·61	0·4626068
B_2	63 8 57	−1·00	56·00	0·8921832	β_2 = +0·506	+1·012	b_2 = −2·928	+1·909	−0·560	y_2 = +1·349	57·35	0·8921862
C_2	89 17 42	−1·00	41·00	0·9999243	..	..	c_2 = −1·410	+0·919	+1·120	z_2 = +2·039	43·04	0·9999244
	180 0 3											
A_3	100 6 13	−4·67	8·33	0·9844961	α_3 = −0·178	−0·356	a_3 = +1·100	−0·717	+0·560	x_3 = −0·157	8·18	0·9844962
B_3	34 28 9	−4·66	4·34	0·5659440	β_3 = +1·456	+2·912	b_3 = −2·734	+1·783	+0·560	y_3 = +2·343	6·67	0·5659534
C_3	45 25 52	−4·67	47·33	0·7123913	..	..	c_3 = +1·634	−1·065	−1·120	z_3 = −2·185	45·15	0·7123839
	180 0 14											
A_4	22 13 51	−2·67	48·33	0·3783270	α_4 = +2·446	+4·892	a_4 = +6·263	−4·083	+0·560	x_4 = −3·523	44·81	0·3783112
B_4	36 5 44	−2·67	41·33	0·5891232	β_4 = +1·371	+2·742	b_4 = −5·188	+3·383	+0·560	y_4 = +3·943	45·28	0·5891387
C_4	121 40 33	−2·66	30·34	0·8510394	..	..	c_4 = −1·075	+0·701	−1·120	z_4 = −0·419	29·91	0·8510405
	180 0 8						$\Sigma(a^2+b^2+c^2)$ = +126·790					

$$\frac{\text{Sin } A_1 \text{ sin } A_2 \text{ sin } A_3 \text{ sin } A_4 \text{ (from column 5)} = 0{\cdot}1612581}{\text{Sin } B_1 \text{ sin } B_2 \text{ sin } B_3 \text{ sin } B_4 \quad \text{''} \quad = 0{\cdot}1612362} = 1 + \epsilon.$$

$$\therefore 1 + \epsilon = 1{\cdot}0001358.$$
$$\therefore \epsilon = +\,0{\cdot}0001358 \text{ radians.}$$
$$\therefore \epsilon = +\,28''{\cdot}01.$$

$C_1 + C_2 = C_3 + C_4 + \epsilon_0$ (from column 4).

$$\therefore 31''{\cdot}67 + 41''{\cdot}00 = 47''{\cdot}33 + 30''{\cdot}34 + \epsilon_0.$$
$$\therefore \epsilon_0 = -\,5''{\cdot}00.$$

$k = \frac{1}{8}\,\Sigma\,(a^2 + b^2 + c^2) = +\,21{\cdot}132$ (from column 8).
$h = c_1 + c_2 - c_3 - c_4 = -\,0{\cdot}795$ "
$i = 4.$

The equations for P and Q are—

$$hP + 2iQ + \epsilon_0 = 0.$$
$$2kP + hQ + \epsilon = 0.$$

Substitute the values of h, k, i, ϵ_0 and ϵ, and the equations become—

$$-\,0{\cdot}795\ P + 8\ Q - 5{\cdot}00 = 0.$$
$$+\,42{\cdot}264\ P - 0{\cdot}795\ Q + 28{\cdot}01 = 0.$$

Solving these equations for P and Q, we obtain—

$$P = -\,0{\cdot}652.$$
$$Q = +\,0{\cdot}560.$$

Checks on Final Angles.

Sin A_1 sin A_2 sin A_3 sin $A_4 = 0{\cdot}1612457$ (from column 13).
Sin B_1 sin B_2 sin B_3 sin $B_4 = 0{\cdot}1612457$

$C_1 + C_2 = 75''{\cdot}06$ (from column 12).
$C_3 + C_4 = 75''{\cdot}06$

ART. XV.—*The Travelled Goat: a Great Lexicographer, a Celebrated Painter, and a Distinguished Botanist.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute, 13th October, 1902.*]

IT seems to me a remarkable fact that, if my thoughts are directed to any particular point or occurrence of which I have had no previous knowledge, I will almost simultaneously meet with this, or similar, information from several sources. Lately, in looking over a number of copies of the *Live Stock Journal*, or possibly the *Field*, dating back some twenty or more years, I came across the mention of the death of a goat which was notable from its having accompanied Captain Cook in his two voyages to New Zealand and round the world, although I forget what date was mentioned. Within a fortnight's time, on looking through Boswell's "Life of Johnson," I find mention of this same goat again, as follows:—

TO SIR JOSHUA REYNOLDS.

DEAR SIR,— Feb. 27, 1772.

Be pleased to send to Mr. Banks, whose place of residence I do not know, this note, which I have sent open, that, if you please, you may read it. When you send it do not use your own seal.

I am, Sir, Your most humble servant,

SAM. JOHNSON.

TO JOSEPH BANKS, ESQ.

Perpetua ambitâ bis terrâ præmia lactis
Hœc habet altrici Capra secunda Jovis.*

SIR,— Johnson's Court, Fleet Street, Feb. 27, 1772.

I return thanks to you and to Dr. Solander for the pleasure which I received in yesterday's conversation. I could not recollect a motto for your Goat, but have given her one. You, Sir, may perhaps have an epick poem from some happier pen than, Sir, Your most humble servant,

SAM. JOHNSON.

To New-Zealanders anything relating to the early history of their country is of interest, especially such as is connected with Captain Cook's voyages; and the value of the service rendered by this animal in producing its small quota of milk may be estimated by our knowledge that sailors and voyagers at that time were greatly subject to scurvy, owing to unsuitable food, and this difficulty and privation is made very evident when Mr. Banks, in his diary, tells us that, Captain Cook being then very ill, a dog belonging to Mr. —— was killed and turned into soup for the nourishment of the sick man, who received great benefit thereby.

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* "Thus translated by a friend:—

In fame scarce second to the nurse of Jove,
This Goat, who twice the world had traversed round,
Deserving both her master's care and love,
Ease and perpetual pasture now has found."—[BOSWELL.]

Boswell makes these following remarks on the voyages :—

"I gave him [Dr. Johnson] an account of a conversation which had passed between me and Captain Cook the day before at Sir John Pringle's, and he was much pleased with the conscientious accuracy of that celebrated circumnavigator, who set me right as to many of the exaggerated accounts given by Dr. Hawkesworth of his voyages. I told him that while I was with the captain I catch'd the enthusiasm of curiosity and adventure, and felt a strong inclination to go with him on his next voyage.

"Johnson: 'Why, sir, a man *does* feel so till he considers how very little he can learn from such voyages.'

"Boswell: 'But one is carried away with the general grand and indistinct notion of a voyage round the world.'

"Johnson: 'Yes, sir; but a man is to guard himself against taking a thing in general.'

"I said I was certain that a great part of what we are told by the travellers to the South Sea might be conjecture, because they had not enough of the language of those countries to understand so much as they have related. Objects falling under the observation of the senses must be clearly known, but everything intellectual, everything abstract—politics, morals, and religion—must be darkly guessed. Dr. Johnson was of the same opinion. He upon another occasion, when a friend mentioned to him several extraordinary facts as communicated to him by the circumnavigators, slily observed, 'Sir, I never before knew how much I was respected by these gentlemen; they told me none of these things.' He had been in company with Omai, a native of one of the South Sea Islands, after he had been some time in this country. He was struck with the elegance of his behaviour, and accounted for it thus: 'Sir, he had passed his time while in England only in the best company, so that all that he had acquired of our manners was genteel. As a proof of this, sir, Lord Mulgrave and he dined one day at Streatham. They sat with their backs to the light, fronting me, so that I could not see distinctly, and there was so little of the savage in Omai that I was afraid to speak to either lest I should mistake one for the other.'"

On this head we must remember that Dr. Johnson had defective eyesight, which would accentuate this difficulty; but there is no doubt but that many of the Polynesian peoples are well capable of acquiring the habits of civilisation. In fact, we are able to notice this at the present time by comparing the Maori of to-day with his ancestor of sixty years ago.

Note.—The place mentioned as where the goat died was either Camdentown or Camberwell, so far as my memory serves. It is unfortunate that I did not make a note of this at the time of reading the paragraph.

ART. XVI.—*The Horse: a Study in Philology.*

By TAYLOR WHITE.

[*Read before the Hawke's Bay Philosophical Institute, 13th October, 1902.*]

IT is the opinion of those who have not attempted to trace the history of the horse into the far-back period long anterior to oral tradition that this animal was originally to be found in the more arid parts of Asia; but of late years, owing to the study by geologists and others of osteological remains, we have certain proof that horses were fairly numerous in a feral state in Europe, and even in the British Isles, so long ago as the time when the man living there at the same period had not yet become possessed of more useful tools and weapons of defence than wooden clubs and unpolished stone implements—the man of the Palæolithic age. We have well-authenticated evidence, by the finding of the bones of horses among those of other animals, that man then used the horse as an article of food.

Quite recently MM. Capitan and Breuil discovered many drawings on the walls of caves at Combarelles, in the neighbourhood of Eyzies (Dordogne), in France. Among these 109 drawings were some fairly good representations of that monster elephant the mammoth, with its shaggy coat of hair and immense upward-curved tusks. The correct drawings of the mammoth among the other drawings in these caves gives us data as to the approximate geological age or period of time at which such drawings were made, for these cave-dwelling people certainly drew the likenesses of animals then living.

The reindeer, which at the present time is only found on the confines of the arctic regions, was also among those depicted. This animal is spoken of by Cæsar as the *rheno*, found in Gaul at the time of the Roman invasion, and it was probably killed off by some infectious disease at a subsequent time, or possibly by an insect plague. The Laplanders of to-day always move their reindeer herds from the coast to the uplands in the interior at the coming of spring to save them from the attacks of insect plagues, notably that of the bot or warble fly (*Œstrus bovis*). One writer speaks of the reindeer being so infested by the large grubs of this fly under their skin that they may be heard to fall on the ground when the beast gives a vigorous shake. This, of course, could only occur at a time when the grubs had reached maturity and so were ripe to leave their host and retire underground, there to remain until by a further stage of development they were

ready to issue forth as the perfect fly. On the other hand, I notice that the larger antelopes of South Africa are liable to suffer from rinderpest, and be greatly reduced in numbers, as are our domestic oxen.

Among these drawings were seemingly two varieties of the horse—the one having a heavy appearance, with a Roman nose or arched frontal, the other being of a lighter type, with slim legs and hogged or short upstanding mane. A most remarkable fact was that some of these horses were seemingly haltered, others had a cord round the muzzle, and two appeared to have some material thrown over the back—a rug or possibly the skin of some other animal.—(*Nature*, 30th January, 1902, p. 300.)

Here we seem to have certain proof that the man of that time utilised the horse as a beast of burden, and held the horse in captivity, or, as we say, it was "a domesticated animal." But as yet, I believe, no figures of mounted men have been reported; perhaps the horse was then only used as a pack animal, and these people do not seem to have been in the habit of making drawings of the human figure—at least, I have no remembrance of ever hearing of the fac-simile portraits of the Palæolithic man. Can they have had, like the Maori of the last century, a superstitious dread of drawing or carving the human figure *in extenso*, the Maori never giving the carving the full number of fingers or toes, by which simple method of abbreviation danger was assumed to be avoided? The Australian blacks had no such scruples, as they drew and carved on trees figures of men and women, which were so roughly executed and were done in such a childlike manner that they give no correct delineation of the form or features. The Palæolithic man of Europe was a far superior artist, and his drawings were genuine rough portraits.

Of all animals the horse is most notable for the wonderful length of the hair in its mane and tail, and, noting this, we may suppose that primitive man may possibly have coined a name for the horse indicative of this unusual characteristic. In French the horse is named *cheval*. Taking as the root of this word *chev*, as seen in *chev-aux* (horses), we may assume a connection with *chev-eu*, hair; *chev-elu*, long-haired; *chev-elure*, head of hair; *chev-et*, a pillow or bolster (because filled with hair); *chev-être*, a halter (possibly from ropes and halters being made from the long hair collected from the horse, and we have fabulous stories of the use of ropes made from the long hair of women in the building of notable edifices). *Chevêtre* is also the binding-joint in carpentry, and in surgery a bandage to support the lower jaw. No doubt the halter of the olden time, made from horse-hair, was passed

around the jaw-bone of the horse, the vacancy between the teeth of the horse being specially arranged, as it were, to accommodate this practice. I can distinctly remember the time when a peculiar formation of horse-hair rope was used to hobble or tie together the tail and hind-legs of cows when they were being milked in the open field. Then, we have *chev-ille*, a peg, pin, or bolt; *chev-iller*, to peg, to fasten with a peg; *chev-illot*, a toggle (the nautical term for a belaying-pin); *chev-ill-ure*, the branches on the horns of a deer, such being useful to the Palæolithic man as pins, pegs, and other tools.

Several of these words may indicate the necessity of holding the horse in restraint, such as the tethering of the animal with a long rope made of hair, at the further extremity of which would be a pin or peg driven firmly into the ground. If the horse was hobbled, a bone or wooden toggle would be used, in place of the buckle of to-day, to pass through the loop on either hobble, which was made of hair, or otherwise of raw hide. In hobbling the cow as mentioned above a similar toggle locked the short rope of hair after it had been passed several times round the beast's hind legs. I should say that the whole method of this proceeding, and the outfit, were remainders from bygone days, previous to the date when man discovered the use of iron and other metals.

La chev-ille des pied, the ankle (literally, the peg, pin, or bolt of the feet). At or near this part of a man the shackles (*fer* or *chaines*) were fastened on the prisoner, the equivalent to hobbles; but *jambe* is the shank, and the shank-bone, or tibia, is *os de la jambe* (or, literally, bone of the shank). This bone of the horse is named *canon*, which we also use in our term "cannon-bone." Skeat derives *canon* through Anglo-Saxon *canon;* Latin, *canon*, a rule; Greek, *κανών*, a rod or rule, *κανη*, a (straight) cane. The cannon of war he derives through French *canon*, originally a gun-barrel, through or connected with Latin *canna*, a reed. I would assume this reed equivalent to a bamboo rod.

The French words are rather confusing in these terms as to what particular part of the leg is meant, for *cheville du pied* is the ankle, while *qui a rapport aux chevilles* is ankled (literally, that which is connected with the ankles); *cou de pied* (literally, neck of the foot) is the ankle-joint, but the ankle-bone is *astragale*, which, I suppose, is not the tibia, mentioned previously, but the part known anatomically under its Latin name *talus*, the ankle-bone (of animals, the pastern-bone or knuckle-bone). *Talus* was also used to denote the heel or foot. It would seem that in olden times this bone was used in place of dice—*talaris*, pertaining to the ankles, also to dice. These must be the bones—if I remember correctly five was the number—used by schoolboys to play knuckle-bone.

The pastern-bone of a horse would correspond with the third bone of the middle finger or toe of a man, and the cannon-bone with that of the foot or palm of the hand. The hock of a horse being equal to the human heel, it seems to me that the word indicates that the ancients realised what is not understandable by the majority of civilised persons to-day —that anatomically the hock of the horse was equal to the human heel. In Dutch *hak* is the heel.

Returning to the word *cheval*, a horse, and its connections, we have *cheval de frise* and *chevaux de frise*, a special or outlying or advanced military protection to a camping-place, which is an arrangement of iron spikes placed on the ground to confuse the charge of an attacking force. This in German is *Spanische reiter* and *Frisische reiter*, which Skeat says is, "Literally, horse or horses of Friesland—a jocular name." So far as I remember, these were a number of iron spikes fastened to a central piece, or a ball of spikes, many of which were placed around the temporary camp, so as to injure the horses in case of a charge of cavalry by the enemy.

The French *cavalé*, a mare, is no doubt an altered variant of the Celtic *capull*, a horse. From *capull* comes the Latin *caball-us;* Greek, *kaball-ēs,* which is the more evident owing to the two latter words being without the feminine form. The correct names for horse are — Latin, *equ-us;* Greek, *hipp-os,* which leads to the inference that these two nations first became acquainted with the horse in an eastern country, and so imported an eastern name for the animal. Note Sanscrit *acva (akva);* Persian *esp*, a horse. Latin *caball-us* denoted a pack-horse, a small horse or pony.

To the French words *cheval*, a horse, and *cavalé*, a mare, we are indebted for many of the English terms denoting the higher classes of society and warlike actions, because in this case the horse was mainly used by the wealthy and for service in battle. The peasant or labourer did not use the horse to till the ground, or to plough, or to cart produce and effects, but used oxen.

It is worthy of special remark that the French have a distinct term to denote the shelter provided for the horse in *écurie*, when that for cattle (*bestiaux*) is *étable*, an ostler or stable-boy being *valet d'écurie*.

To house or stable cattle is *établer*, but of horses *loger*, from *logis*, a house or lodging, as seen in the signboard notice: "*bon logis à pied et à cheval.*"

We English speak of a partially enclosed building for cattle as a cowshed, but the Scotch have *byre*, a cowhouse, connected with Anglo-Saxon *býre*, dwellings, plural of *búr*, a chamber, a *bower;* Icelandic *búr*, a chamber. Here we form

an unexpected contact with the old days of *chivalry* in the familiar term "In my lady's bower."

But we have a reverse picture in Dutch *boer*, A.-S. *bûr*, *gebûr*, a peasant, from A.-S. *búan*, to till. Presumably the cultivation of the soil necessitated the husbandman dwelling or residing at that place, as seen in English *neigh-bour*, A.-S. *néah-bûr*, one who dwells *near* to another.

From this vantage we can, as it were, realise the time when man and his oxen were housed under the one roof or fortified enclosure, being thereby protected from the depredations of enemies, whether man or predatory animals.

Before giving these names I may mention the Italian for horse is *cavallo*, while *cavalla* is a mare. The Latin *equ-us* and *equ-a* are obsolete, only showing in such terms as *equ-i-tazione:* French, *equ-i-tation*, riding; *equ-i-seto*, horse-tail, or "mare's-tails" (a river-weed), &c. The ordinary terms are *caval-cata*, riding; *cavall-one*, a large horse; *cavall-ino*, a colt: French, *pouliche*, *poulin*, *bidet:* Italian, *cavall-ina*, a filly; *caval-acchio*, a wasp (likely the horse bot-fly—*Œstrus equi*).

For names denoting nobility we have the Italian *cavalier;* French, *chevalier*, *cavalier*, a knight: Italian, *cavall-eria;* French, *cheval-erie*, knighthood: Italian, *cavall-er-esca-mente*, gallantly, gentleman-like; French, *de bonne grace*. Here, to remark on the word "gentleman," how few of us really appreciate the original and true meaning—that such a one by training is of kind actions and thoughts, and in the habit of conversing in a subdued tone of voice (*i.e.*, gentle). At the close of the reign of Charles I. we read of the war between the Royal subjects (the Cavaliers) and the Round-heads.

For the reverse picture: Italian, *cavalier d'industria;* French, *chevalier d'industrie*, a sharper, fortune-hunter, "soldier of fortune," one who sells his fighting abilities to a foreign country. The old-time yeoman or farmers of the Scottish border were required by the terms of their lease to maintain one horse capable of carrying its owner a distance of twenty-five miles on a foray over the border and returning without obtaining any fodder during the time occupied by the raid. The knight of old—say, during the time of the crusades—was by his knightly oath constrained to order his conduct by certain rules of knighthood. He was to take no mean advantage against those contending with him in fight or in combat or in the tournament, was to succour or defend the oppressed (especially women), and was usually attended by an esquire or squire, who was generally a youth of good birth. The duty of the esquire was to see to the armour and *destrier* (war-horse) belonging to the knight whom he attended, &c.

Now, it is extremely curious to find that at a more distant date the word "knight" in kindred languages chiefly means "a groom," one who attends to horses, as in German *knecht*, a man-servant; *reiter*, a rider, horseman; *knecht*, a groom: Dutch, *knecht*, a servant: Danish, *knegt*, a man-servant, the knave (at cards): Swedish, *knekt*, a soldier, knave (at cards): German, *stall-knecht*, an ostler; *fuhr-knecht*, an under-carter (from *fuhren*, to carry).

The original form of the word "esquire" dates back to the far-off time when chariots were drawn by a pair of horses, and at times carried three men in battle—one person was the driver, the second the warrior, while the third bore the shield (Latin, *scut-um*), and was named therefrom (*scut-arius*). This in French becomes *écu*, a shield, and *écuyer*, a shield-bearer; but *ecuyer* is now used to denote "esquire," "squire," "equerry" (not from Latin *equ-us*, a horse), also "riding-master" and "rider," and the English word "esquire" is derived therefrom. The French say, *Il est bon ecuyer*—he is a good horseman; *ecuyère* is a female equestrian performer; and *ecuyer de cuisine* is the *chef* or head cook in large establishments. A further explanation is found in *titre donné en Angleterre au proprietaire le plus influent, mais non noble, d'un village*, which I translate—a title given in Britain to a freeholder, the most influential, but not a nobleman, in any village.

In German "shield-bearer" and "esquire" are given under the same words as *schild-fuhren*, *schild-knappe*, *schild-knecht*, *schild-träger*; but on letters *wohl-geboren* (of good birth, gentleman) is written as a title of courtesy in place of our British method of affixing "Esq." to the addressee's surname. In German *schild-burtig* means of gentle blood.

Now, the aforementioned shield was formerly (that is, previous to the discovery of the process of mining and forging metals of bronze, iron, &c.) a tough portion of hide or skin secured to a light framework of vegetable material, such as willow or hazel twigs. This is readily seen in the etymology of the word *cuir-ass*, a breast-plate, from old French *cuir-ace*, a cuirass: French, *cuir*, leather: Italian, *corazzo*, a cuirass; *corio*, the skin; *corame*: Latin, *corium*, leather: Lithuanian, *skura*: Greek, *chorion*, a hide: from which also are the English words *ex-cori-ate* and *scourge*, and the Italian *s-curi-ata* and *s-curi-ada*, a scourge, a whip, which, after the manner of our stockwhip, would originally be made of raw hide. The Italian *scuro* (ob-scur-e), unknown, and *scur-are*, to become dark, seem closely allied to the above. Here the idea is "dark when shaded or covered up," as in our two forms—*hide*, to cover (Anglo-Saxon, *hýd-an*), and *hide*, a skin, or more especially a flayed skin (Anglo-Saxon, *hýd*, the skin—

i.e., the cover; Latin, *cutis;* Greek, *kutos* and *skutos*, skin, hide; Sanscrit, *sku*, to cover; Latin, *scutum;* Greek, *skutos*, a shield). Then, in Italian we find *scu-do*, a shield, a buckler, an es-cut-cheon—*i.e.*, a shield having a painted device or bearing the coat of arms of the user (German, *wappen-schild*). This is of a later date, at which time the knight carried his shield himself, and his esquire was not required to join the fray unless it was a general encounter of numbers, when he would fight for his own party with "sword and buckler."

The Italian *scu-da-jo* was a maker of bucklers or shields, *scuderia* a stable, an equerry (French, *écurie*), and *scudiere* an esquire, gentleman of the horse (French, *écuyer*). Here we see a proof that the shield was shelter for the man and the stable was the shield or shelter for the horse. The horse therein was "shielded" from the weather. We probably have the same in Irish *shielin*(?), a hut or humble residence: Icelandic, *skjol*, a shelter, cover; *skýli*, a shed: Danish and Swedish, *skjul*, a shed: Anglo-Saxon, *scild*, a shield. Then we have the Italian *scudo* and French *écu* connected together as a so-called crown-piece—a piece of money, possibly made from stamped or embossed leather—which must go back to a very early date in the use of money—or promise to pay on receipt of a symbol (French, *écuage*, scutage, land-tax). "Scutage," likely, is payment levied on the use of a coat of arms and family crest as shown upon the escutcheon or shield and panel of a carriage.

The word "equerry," according to Skeat, is so spelt owing to a supposed derivation from Latin *equ-us*, a horse; it denotes "an officer who has charge of horses and stables." "Properly, equerry means a stable, and modern English equerry stands for equerry-man, from French *écurie;* old French, *éscurie*, a stable; low Latin, *scuria*, a stable; old High German, *skûra, skiura* (German, *schauer*), a shelter, a stable."

In German *stall-meister* is given as an equerry, master of the horse, riding-master; *stall-junge*, an ostler, groom (*stall*, a stable; *junge*, lad or boy). This latter will remind us of the old custom of naming the postillion, or he who rode the near-side horse of the pair drawing a hired post-chaise or carriage, the "post-boy," although he might be a man grown old and wrinkled in the service. Postillion: Italian, *post-iglione*—*post-a*, a place, a post-house, also *post-o*, the same; and *postière*, a postmaster, all from Latin *pon-ere*, to place. The original meaning is "certain distances along a road at convenient length"—Latin, *ponere*, to place or fix a station or standing-place; *sta-re*, for *sta-are*, to stand; *sta-bulum*, a stable (for post-horses) where the traveller could change his tired team for fresh horses; sometimes also named a

"change-house." From this custom in course of years our wonderfully intricate "postal service" has been evolved.

Like the Kirghiz of the present day, old-time peoples made great use of hides and skins, not only as personal clothing (note the sheep-skin clothing of the Russian peasant), but as a covering for their moveable shelter, used as houses or tents, and no doubt at inclement seasons the horse lived under the same shelter as his owner.

We would naturally assume that a currycomb would trace back to words referring to skin or hide, but Skeat says, "A hybrid word, made by prefixing *con* (Latin, *con*, *cum*) to old French *roi*, order," and that "the old saying 'to curry favour' is a corruption of mid-English 'to curry favel' (to rub down a horse). *Favel* was a common old name for a horse.

The philological results occasioned by the use of the horse as an agent to carry man from place to place with speed, and as a help in war, is well shown in the accompanying words in the German language, all derived from the word *ritt*, a ride, riding (from *reiten*, to ride): *ritt-lings*, astride, astraddle; *ritt-meister*, a captain of horse; *ritter*, a knight, a cavalier (also as a prefix, in composition, means "knight's," "knightly," of chivalry); *ritter-akademie*, an academy for young noblemen; *ritter-burtig*, of knightly descent; *ritter-gut*, a manor, a residence for a nobleman; *ritter-lich* (literally, rider-like), knightly, chivalrous; *ritter-spiel*, a tournament; *ritter-kuss*, gallantry; *rittern*, to knight, to contend (the allied word *st-reiten*, to combat, to fight, from *reiten*, to ride, may be here mentioned); *ritter-saal*, a hall where knights assemble; *ritter-schaft*, knighthood, chivalry, body of knights; *ritter-sporn*, the garden plant larkspur; and *ritter-zug*, adventures of a knight errant, a crusade. This list of words will amply support the contention that the horse has been a main agent in elevating the standard of humanity, the more especially owing to his being used to forward the religious mania of the Crusaders to recover Palestine from the Panim Saracens. German, *kreuz-zug*, the crusade, from *kreuz*, the cross, literally means "the expedition or march of the cross."

The present Duke of Portland, as Master of the Horse, which, I believe, is a designation distinct from "equerry," is thus spoken of in the *Worksop Guardian* just previously to the ceremony of the coronation of King Edward VII.: "The Duke of Portland has, of course, to hurry back to town from Welbeck, his official duties on Saturday next demanding his presence there. The Duke has for some months past personally watched and supervised the arrangements which devolve upon his department, and the work is no sinecure. At the Royal Mews the Duke is very

popular; but, although he is kind, his firmness and strict adherence to discipline and perfect working are recognised and respected." The Royal Mews now means a range of stabling, because the Royal stables were rebuilt (A.D. 1534) in a place where the Royal falcons had been kept. The name is derived from mid-English *mewe*, *mue*, a cage where hawks were kept.

A second newspaper cutting, also having reference to the preparations previous to the coronation, is here given in part: "In the death of the Earl of Arundel, only son of the Duke of Norfolk, and heir to the premier dukedom and office of Hereditary Earl Marshal of England, a feeble flame of life flickered out at Arundel Castle on Tuesday, the 8th July, 1902. . . . His final illness began on what was to have been Coronation Day [postponed owing to the King's illness], and the Duke of Norfolk, one of the best and most devoted fathers, was summoned from the turmoil of the Earl Marshal's office to his bedside by telegram." In German this title is *Ober-hof-marschall*, Chief Marshal of the Household; Skeat says "marshal" means master of the horse, and literally horse-servant, but the word is mostly used now to denote a civil officer who directs processions, and no doubt the duty of the Earl Marshal of England would be to arrange the order of the coronation procession. It would seem that the term "Master of the Household" will not necessarily refer to domestic arrangements, for we speak of "Household Troops," and the German word *hof*, after the manner of our word "court," originally designated an enclosed farm-yard, so dating back to the time when it was necessary to enclose their house and domestic animals in a court-yard (German, *hof-raum*), and in course of time, as man progressed in civilisation, or shall we call it "luxury," *hof*, a farm-house, came to mean "the Royal Court," not an enclosure, but the Royal retinue; also our English "Court," a judicial assembly. An allied word is *court-ege*, a train, a retinue; *courtier* and *curtsey* (the same as "courtesy"), a courtly act.

The word "marshal" is a remarkable relic of the male form of our word "mare," the feminine of horse, and Skeat gives it as literally "horse-servant," a groom, which has risen to be a title of honour, from old French *mare-schal* (French, *maréchal*), a marshal, a farrier, through old high German *mara-scalk* (*marah*, a horse; *scalk*, a servant). *Stute* would seem the more usual word for mare: *Stut* = English "stud," as in "stud mare." We also find in German *märe* and *mahre*, a mare, a nag, a jade; *mar-stall*, the Royal stables; *mar-stall-herr*, a master of horse; *mähr-es*, *mähr-en*, the nightmare; *mähr*, *mähre*, tidings, report; *mähr-chen*, legend; *mähr-chen-haft*, fabulous (note English "mare's nest").

Art. XVII.—*The Fight against Tuberculosis in the Australian Colonies and New Zealand.*

By John P. D. Leahy, M.B., D.P.H.

[*Read before the Hawke's Bay Philosophical Institute, 19th May, 1902.*]

Though I realise that possibly at first sight this question might be considered as one of interest rather to the medical profession than the public at large, yet, as I hope to be able to point out, the question at the present time is very greatly one for the public, and our strongest hope for effectually crushing this formidable foe lies in an intelligent understanding by the people of the nature and magnitude of the evil and its remedy.

Doubtless many of the things I shall bring under your notice are already known to you, owing to the active and increasing interest taken by the Press and public in questions of public health. Tuberculosis is a question receiving world-wide attention, not only of scientific men but of educated laymen. The scientist knows the cause of the evil and the means of combating it, but the public must be the conquering army laying that evil low.

This paper is intended to show not what is being done in the world generally to combat tuberculosis, but to point out what is being done nearer home—namely, in the Australian Colonies and here in New Zealand. Before doing so, however, it would be well first of all to state briefly a few facts concerning the causes of tuberculosis. These are so well known that my excuse for mentioning them here is solely that your memories may be refreshed on the subject.

In 1882 Koch demonstrated that tuberculosis in every form was due to a minute organism which he named "the tubercle bacillus." Bacilli, as you know, belong to the lowly form of vegetable life known as the fission fungi. Reproduction occurs with great simplicity and marvellous rapidity. A rod-shaped organism or bacillus splits into two halves, which rapidly grow to full size, when each splits again into two, and so on in a geometrical progression until in a very short space of time, under favourable circumstances as to food-supply, &c., a single bacillus will give rise to millions. The individual bacilli are microscopically minute, much smaller than the dust-specks seen floating in a sunbeam, so that if the bacilli are present in the air nothing is easier than to fill our lungs with such air containing large numbers of these organisms ready to attack us and establish the dread disease. Should the tubercle bacillus lodge in a part of the body—say, for

instance, the lungs—and find the locality favourable for its growth, it begins to multiply, damaging the tissues badly during the process, and the condition known as tuberculosis of the lungs becomes established. The point to be emphasized here is that every form of tuberculosis is caused by the tubercle bacillus, and by it only, and therefore the eradication of tuberculosis means the eradication of the tubercle bacillus.

Under ordinary circumstances tubercle bacilli are extremely tenacious of life, though with suitable means they may be easily killed. The sputum of consumptives teems with these organisms, and is the most prolific means of spreading infection. So that clearly this is a question requiring serious consideration.

We have all observed the absence of dust inside our homes as well as out-of-doors in damp weather, the reason being, of course, that the moisture in the atmosphere condenses on the particles of dust in a room, overweights them, and they sink down and settle on the floor or walls, the air so becoming clarified. I mention this every-day fact to make clearer a point I wish to bring out—namely, that it is not the sputum or spittle just when dejected from a patient in a moist condition and so containing the bacilli in certain confined limits that is the trouble, but the danger arises when the sputum dries up, becomes pulverised, and floats about in the atmosphere, to be breathed in by all and sundry.

We do not all get tuberculosis, though frequently exposed to risks, any more than we get many other diseases; that, however, is another question, introducing the subject of immunity, which it is not within the scope of this paper to discuss. Suffice it, then, to summarise thus:—

(*a.*) Tuberculosis in every form is due to the tubercle bacillus.

(*b.*) The most fertile, if not the only, source of human tuberculosis is the sputum of consumptives allowed to dry and get converted into dust, so contaminating the air.

(*c.*) Tuberculosis is infectious.

(*d.*) Tuberculosis is preventible.

Tuberculosis is, then, an infectious disease, and any person, place, or thing contaminated by the expectoration of consumptives is a focus of infection for human beings. Hence houses or rooms inhabited by consumptives are infectious, as has been sufficiently proved many times; also handkerchiefs, &c., used by such persons are obviously infectious, and the filthy habit of indiscriminate spitting is a prolific source of infection.

I think the above is sufficient explanation of the main factors in the spread of tuberculosis so far as is relevant to

this paper. Let us now consider what we in the colonies are doing in the matter of checking the evil, and so take up our subject proper. I will begin by first stating how things stand with us in New Zealand, and then compare the other colonies.

During the last two decennial periods there has been on the whole a steady decline in the death-rate from phthisis in New Zealand. In 1900 the figure for phthisis stood at 7·56 per 10,000 living, and for all forms of tuberculosis 9·85. The deaths from tuberculosis represented as a percentage of total deaths equalled 10·44 in 1900. Practically throughout the last decennial period phthisis heads the list of all causes of death. The New Zealand Year-book contains the following paragraph *re* phthisis: "In all the Australian Colonies the rate is materially increased by the deaths of persons who have come out either already suffering from phthisis or predisposed thereto. There is no reason for believing that this circumstance has more effect on the death-rate in Australia than in New Zealand; so that the lower rate referred to in previous issues of this work as obtaining in this colony may be taken as proof of its superior climate for withstanding consumptive tendencies."

The Health Department here has issued circulars and handbills, also large-type placards, on tuberculosis, which latter are posted up in public places, and the former widely distributed. The language used is plain and free from any technicality, and points out that tuberculosis is an infectious disease, exhorts people not to spit in public places, explains the necessity for disinfection of infected rooms, &c., and how consumptives should deal with their sputum in order to minimise the risks of infection of others.

Our Public Health Act of 1900 is a very up-to-date Act, and provides for the notification of infectious diseases (in which are included all forms of tuberculosis). The occupier of the house, as well as the medical attendant, has to notify every case of tuberculosis. When the disease has been notified the Act provides for disinfection of infected premises. A penalty is provided for selling infected things, or letting houses or rooms where an infected person is lodging. The Act also deals with the question of overcrowding. "The Factories Act, 1901," deals with the notification of persons suffering from tuberculosis if engaged in the handling, &c., of any article for human consumption. It deals also with persons working up goods or materials in infected dwelling-houses. Our local bodies have power to make by-laws against spitting in public places; Wellington and Christchurch have recently made such by-laws, Auckland and Wanganui are moving in the same direction, and doubtless many other places will follow a similar course. The railway authorities

have no by-laws or regulations dealing with this subject. The Veterinary Department is doing excellent work, aimed at the eradication of tuberculosis in cattle, and has very full powers; and "The Dairy Industry Act, 1898," deals satisfactorily with the subject of milk from diseased animals and insanitary milk-shops, &c. The last thing to be mentioned, though, as often, not the least important, is the question of sanatoria, and the Government has already made a move, and ere long we may hope for at least one sanatorium in each Island. Thus, as briefly as possible, I have outlined what we in New Zealand are doing in the fight against tuberculosis; and, as will be seen immediately, we are second to none of the other colonies, and in some things a good deal ahead of them.

Now to consider what the Australian Colonies are doing.

Notification.

In New South Wales and Queensland there is no notification of human tuberculosis, but houses are disinfected in which persons have died from phthisis.

Victoria has no compulsory notification, but the Board of Health invited information from ratepayers and District Registrars of cases of consumption and deaths from that disease, and undertook the disinfection of premises. Melbourne has volunteered to look after the matter, and local Registrars report all deaths from tuberculosis, and then the local authority carries out disinfection of premises. Outdoor hospital consumptives are notified, and then their homes are visited and instructions given.

South Australia, like ourselves, has compulsory notification on practically the same lines; its Act was passed in 1898, two years before ours.

Tasmania has no notification.

West Australia has notification of pulmonary tuberculosis.

From this it will be seen that South Australia and New Zealand are ahead of the other colonies as regards notification, meaning that, whereas the other colonies only disinfect premises after persons have died in them, the two colonies mentioned can disinfect every time a person changes his place of abode.

Meat and Milk.

Most of the colonies have legislation on the subject of meat and milk.

Queensland has been very behind-hand in the matter, but under the *régime* of the newly appointed Health Commissioner there is promise of more efficient control.

Again South Australia and New Zealand go hand-in-hand with municipal abattoirs, the only efficient method of dealing with diseased meat.

In many of the colonies dairy inspection is anything but satisfactory. To quote a Victorian writer on the subject, "Very few Councils have appointed veterinary inspectors, dairy inspection being often but one of the duties of an officer whose functions are as multifarious as those of 'Pooh Bah' of operatic fame."

Spitting.

New South Wales local bodies have power to deal with this nuisance, and Sydney has with great success enacted by-laws against street spitting, and so strictly carried them out that their success in purifying the condition of the pavements is astonishing. Efforts are being made to prevent spitting in tramways, trains, and public vehicles of all kinds.

Queensland has similar powers to New South Wales, and Brisbane has municipal by-laws against street spitting. The railway authorities have also passed by-laws against spitting, which, however, they have failed to carry out.

Victoria and South Australia have no legislation against spitting.

Tasmania has the pride of place in the colonies in this matter, as Hobart and Launceston, in 1896, first of all the colonies made by-laws against spitting in public places.

West Australian local bodies have powers, if willing, to make by-laws on the subject.

Sanatoria.

New South Wales has a hospital for consumptives near the Blue Mountains. It has forty beds, and is maintained entirely by public benevolence. Incurable cases are not treated there, many such cases being treated for a time in the general hospitals. Incurable pauper cases are treated in the Government asylums, and many sufferers from advanced phthisis are cared for in their last days at Saint Vincent de Paul's Hospice for the Dying in Sydney. The Government, however, has promised to take the matter up, and to erect immediately a temporary wooden sanatorium, pending the erection of a permanent structure.

Queensland has two sanatoria for consumptives, one in the Darling Downs, of fifty-five beds, and another larger one on the Diamantina.

South Australia has a sanatorium for fifty persons near Adelaide, and the Government intends shortly to provide accommodation for incurable cases.

Victoria has the Austin Hospital for incurables, which has a special wing set apart for advanced cases of phthisis, containing forty beds. There is also the Consumptive Sanatorium, established twelve years, a charity supported by public benevolence. This has two branches, one at Echuca, for forty patients, which establishment is not self-contained, being more of a convalescent home, the patients going out into the town and parks in the day-time. Patients go to Echuca in the winter, and to the sanatorium at Macedon, which is self-contained, for the summer.

West Australia and Tasmania have no sanatoria for con sumptives.

From the facts mentioned in the above paper it will be readily seen that we have little or nothing to learn from our Australian cousins in the way of grappling with the tuberculosis curse, and we have ample powers in our Public Health Act for guarding the public health.

I think all will agree that this subject of tuberculosis is one deserving great attention, as the consumptive is often the family bread-winner. If he can be cured by any means let us cure him; the less the State does for him the more burden he becomes. His case is not like that of many deadly diseases of short duration, his illness often being protracted for years, during which time he becomes of less and less use to the State and a source of danger to others. So from purely economic if from no other motives let us do all in our power for him, while at the same time we wage a deadly war against the enemy which has crippled him and so many millions of the human race.

ART. XVIII.—*Malaria and Mosquitos.*

By ERNEST ROBERTON, M.D.

[*President's Inaugural Address to the Auckland Institute, 9th June, 1902.*]

IT has been the custom of our Institute since its foundation that the President should, at the inauguration of each series of winter lectures, deliver an address. In choosing my subject for to-night I have followed the precedent set by most of those who have previously occupied this chair in selecting a subject not directly connected with our Institute itself, but one which has general interest for all those who are concerned in watching the progress of science.

The latter end of the nineteenth century has been very fruitful of discovery in the realm of preventive medicine, and

one of the latest and most important of these discoveries has been that of the causal relation of the mosquito to malaria. We have no primary malaria in New Zealand—*i.e.*, none originating in New Zealand; but the subject is, especially at the present time, when so much rivalry exists among colonising nations, of the gravest concern to all engaged in the work of colonisation, or in that of carrying the benefits of civilisation or religion to those parts of the inhabited globe which have not yet come under their influence. It is of special concern to such civilised lands as India, Italy, and some parts of America, where malaria has to be reckoned with as a serious hindrance to the material prosperity of the country.

The importance of the discovery that mosquitos play a part in the dissemination of malaria can be realised only by those who have some knowledge of what a powerful influence that disease has had in retarding the settlement and development of new lands, or in the impoverishment of so rich and ancient a nation as Italy. To-day tropical Africa is still a comparatively unknown land, although European settlements have existed along the coasts for centuries. Exploration of the interior has been difficult; the opening of it to commerce and civilisation has proved a gigantic task, as yet hardly more than begun, mainly because of the malarial fevers which have been met with, and which have so often either turned back the explorer or merchant or claimed him as their victim.

A similar story is to be traced in the history of the colonisation of twenty centuries and more ago. When the Greeks sought to found the colonies in northern Africa or southern Europe the fevers they met with were as formidable opponents as the inhabitants of the lands they wished to occupy. It is recorded of the foundation of Rome itself that its site was chosen because it was a healthy spot, although in the midst of a district where fevers were prevalent. When the Romans later carried their civilisation by force of arms westward and northward the same fevers were to be feared and reckoned with.

More than once in comparatively recent history has an army returned vanquished, not by the foe it set forth to meet, but by malarial fevers. One memorable instance in the history of our own nation is the ill-fated Walcheren expedition; another the attack on the Spanish colonies of Central America, which ended in the disaster at Cartagena.

It is estimated that in India there die annually from fever (mostly malarial) five million people. Of our army there (including Europeans and natives) one-third suffer every year from malaria. The loss to individuals and to the nation from the incapacity thus occasioned cannot, of course, be accurately gauged, but can to some extent be understood from the immense death-rate just mentioned.

As regards Italy, an Italian writer of repute (Celli) states that the activity and progress which at the present time is so distinctive of northern Italy compared with the other parts of that country are in a large measure due to the absence of the fevers so frequent in the southern districts—the Roman States and Naples. A few years ago a society in Rome, having as its object the study of malaria, justified its foundation by stating that the disease prevented the cultivation of 5,000,000 acres of Italian soil, annually affected some two millions of its inhabitants, and killed about fifteen thousand.

In some of the British colonies malaria has doubled the cost of government. During the year 1896 28½ per cent. of the Government servants on the Gold Coast had their services lost to the State through death or ill-health due to it. An old neighbour of our own, Sir William McGregor, at one time in Fiji, later Governor of New Guinea, and now of Lagos, has stated that the Town of Lagos needs only one thing to make it a great commercial centre, and that one desideratum is the control of malaria.

The presence of such a scourge has naturally incited attempts to prevent its occurrence. For centuries there has been a continued effort in this direction. The study of the disease from the point of view of those concerned with the care of the public health has at times been rewarded with partial success. Certain points in connection with its occurrence were early noted, more especially its prevalence in marshy or swampy places. As districts became better cultivated, and so better drained, the presence of intermittent fevers was less and less felt. We find that in early Roman times certain parts of the country around Rome were methodically drained by means of extensive and complicated systems of underground channels. These districts lost their then unhealthy character and became thriving and populous. Later, owing to civil war and consequent neglect of cultivation, the drains became obstructed and the unhealthy conditions returned. The populations of once thriving villages and farms was gradually reduced, and finally the few survivors fled to a less pestilential part of the country. Their dwellings now form some of the ruins of the Roman Campagna. Attempts to repopulate these districts were made from time to time, but were attended uniformly by failure.

Parts of England, also of France and Germany, have within comparatively modern times been very subject to malaria. The drainage of low-lying lands was, no doubt, the cause of its gradual extinction, an extinction, however, not entirely complete, for sporadic cases are met with now and again.

Although, however, it was recognised that the drainage and cultivation of swampy lands in some places played an important part in lessening the fever, the reason of this was not understood. In equally swampy districts no malaria at all was to be found. In other places where there were no swamps and good cultivation it was prevalent. In some districts of India cultivation seemed rather to increase the unhealthiness of a place in regard to fever; but, then, the growing of rice necessitated the presence of surface water during certain seasons. It was evident that neither the state of cultivation nor the absence or presence of swampy lands were in themselves a full explanation of the absence or presence of malaria. We now know such influence as the drainage of the land had was due to the destruction of the breeding-places of mosquitos.

It was noted that very frequently the excavation of earth was followed by a sudden outbreak of malarial fever. In Hongkong such an outbreak occurred on one occasion among the soldiery of an English regiment, near whose barracks some excavations were in progress. The same has frequently been noticed in other malarial countries where railway cuttings or similar works were in progress. The explanation is that these works cause the formation of irregularities in the surface of the ground, in which water collects and forms suitable breeding-places for the mosquitos. Until recently these incidents were regarded as evidence that the fever was due to "emanations" from the disturbed earth.

What has stood in the way of prevention has been that the essential cause of malaria has not been known. Speculations in regard to it had been very numerous, but no satisfactory explanation had been given; and, as is apt to be the case under such circumstances, the want of knowledge was cloaked by the use of vague terms expressing speculative theories as to the origin of the disease.

Malaria is known under many names; some, such as "ague" and "intermittent fever," have been given from the symptoms the fever presents. "Malaria" itself is a term expressing merely the opinion that it arose from unhealthy air. Similarly we find the supposed cause named "marsh miasma" or "paludinism"; of later date is the term "telluric poison," this term coined after its supposed connection with emanations from the soil was brought into prominence. So late as 1886 a standard text-book defines malaria as an "earth-born poison for the most part generated in soils the energies of which are not expended in the growth and sustenance of healthy vegetation." Analysed, this very vague definition is only an evasion of a confession of ignorance. Under such circumstances there was little hope of coping

successfully with the disease. "So long as its cause was unknown the methods of treatment were empirical, and so long as there was no definite notion of the mode in which it was disseminated efforts to prevent it were imperfect and to a large extent futile."

The same vagueness which until recently characterized our knowledge of malaria was characteristic also of many fevers, but the number of these has been much reduced during the latter half of the nineteenth century, owing to the birth of what is known as the "germ theory." It was shown that some diseases were due to the presence in the body of certain small organisms or germs. The importance of this discovery was so great that, as is often the case under similar circumstances, there was a tendency to explain the origin of pretty well all diseases by the "germ theory." Investigators setting to work at some disease with this as a working hypothesis easily persuaded themselves that some germ they had found was the cause of the disease. In some instances these discoveries were confirmed, but in numerous other cases it was shown that the enthusiasm of investigators had led them astray. Malaria was one of the diseases which certain observers were prepared to ascribe to bacilli they had discovered in malarial patients, but these observations were not confirmed.

There were so many false hopes raised in this way that the announcement of a new discovery of the kind was at last regarded with great suspicion, and when it was reported that a French military surgeon in Algiers, named Laverau, had found certain peculiar bodies present in the blood of malarial patients, and in the blood-cells of malarial patients alone, his opinion that they were the essential cause of malaria was not much regarded. His work, however, stood the test of time, and after many years was confirmed by other scientists, and received recognition at the hands of even those who had previously thought they had reason to think a bacillus responsible for the disease. These bodies found by Laverau were not bacteria. They were more closely allied to the group of low organisms called *Coccidia.* These bodies are very insignificant, but it was noticed that they underwent growth and other changes in the blood-cells, the last stage consisting in their rupture and the liberation of spores, which serve to begin another cycle. It is interesting to note that this cycle corresponds in length of time with the period from the beginning of one attack of fever until the beginning of the next. It was shown also that there were different varieties of parasite, some taking longer than others to go through the cycle. This corresponded with what was already known about malarial fevers—that one kind took two days, another three, from the beginning of one attack to the beginning of another.

A practical result of this decision that parasitic bodies were the cause of malarial fever was investigation as to their origin, whence and how they reached the blood of man. This question baffled all observers for many years. The clue to its solution was given by the observation that some of the malarial parasites in specimens of blood examined some minutes after its removal from the body exhibited a change, in which processes ("flagella") grew out from them, these processes finally separating from the parasites and moving off on their own account.

Now, some living creatures of a low order have the peculiarity that their life-cycle varies with their environment, and it was known that some organisms very similar to this protozoon of malaria developed under special circumstances just such moving bodies as these flagella as the first stage of a new cycle of development. This was suggestive. There must, of course, be some purpose served by these flagella, and that purpose apparently had nothing to do with the life of the parasite within the body of man, since their appearance was always subject to the removal of the parasites from the body. Granted so much, and it followed that the malarial parasite had a second life-cycle apart from man of which these flagella were a necessary phase. It was Dr. Manson who argued thus, and he went still further. He was of opinion that the only natural means by which the parasite and the blood containing them was likely to be removed from man was through the agency of some blood-sucking insect. He suggested the mosquito. He was biassed in favour of the mosquito, because he had already shown that it was the intermediate host of another human parasite, a minute worm called *Filaria*.

(I may state here that there was a long-standing tradition among the peasants of Italy that malaria and mosquitos were in some way connected; and among certain tribes in German East Africa not only is the same belief held, but the same word is used both for malaria and the mosquito.)

Manson suggested that when the mosquito had sucked malarial blood the parasites developed these flagella in the stomachs of the insects, and these moved off through the stomach-walls to other parts of their bodies, and then in some way, after further development, once more reached a human host. Manson suggested that the mosquito either died in water or that its body was washed or blown into water which was afterwards drunk by a man; but this part of his theory proved incorrect. Manson was in London himself, and had no opportunity of experimenting to test his theory, but his lectures made a great impression on an army surgeon named Ross, who had already done some

work on the subject. On his return to India Ross set to work at long and patient investigations which were finally crowned with success. He proved definitely that mosquitos were the carriers of malaria, and pointed out the way in which infection through them happened. Ross's full story, apart from his scientific work, has not yet been published, but enough is known of it to enable us to assert that it was only his indomitable perseverance in the face of many difficulties, if not actual opposition, which made success a possibility. The catching and dissection of insects is a hobby which even within walls devoted like our own to the furtherance of science does not always secure unstinted praise, and the catching and microscopic examination of mosquitos did not meet with the approval of Ross's immediate superiors. During the progress of his voluntary investigations he was for a time sent to a station where he had no opportunity of studying the subject. This fortunately was not until he had done sufficient to attract the attention of the scientific world.

Ross began his investigations by searching for the malarial parasite in mosquitos. To this end he examined many hundreds after they had fed on malarial blood. He found readily enough that the flagella developed in their stomachs, but he could not trace them further. By chance, however, he came across a few dappled-winged mosquitos of a kind different from those he had hitherto experimented with. Examining these a few days after they had fed on malarial blood, he noticed something which he had found in none of the other mosquitos. The walls of the stomach were studded with peculiar little saccular bodies, which contained a pigment very like that of the malarial parasite. These cells he noticed were capable of growth, since they enlarged from day to day. It was at this stage of his work that Ross was obliged to give it up on account of his transfer to another station. He had, however, created a good deal of interest in what he was doing; so much so that after a time he was relieved from military duty and sent to Calcutta to continue his investigations. Unfortunately, it was a time of year when little ague was to be met with, and he had difficulty in getting material to experiment with. In this dilemma he turned his attention to a form of malaria in birds. He found that certain species of mosquito fed on malarial sparrows showed growths in the walls of their stomachs very similar to those we have mentioned; but he went further. He bred young mosquitos from the larvæ, and when these were fed on malarial sparrows he found these growths in a large percentage of them. Of those fed on blood which was non-malarial none showed these growths in their stomachs. He found, indeed, that the number of growths was roughly proportional to the number of

parasites to be found in the blood on which the mosquitos had fed. This proved definitely that these pigmented cells were developed from the malarial parasite.

Light was thrown on the way in which the process of development occurs by an American observer, McCallum. He showed in another bird parasite that the purpose of the flagella was to fertilise others of the parasite which did not form flagella. The flagella entered into these and mixed with their substance, which underwent certain changes, as a result of which the form altered into a somewhat conical body endued with power of locomotion and penetration. If the vermicule met with a blood-corpuscle it apparently bored right through it. These stages of development have since been shown actually to occur in connection with the malarial parasite of man, and it has been shown that it is a vermicular form which is able to penetrate the wall of the mosquito's stomach and there developes into these sac-like bodies.

Ross, then, had traced the malarial parasite of birds as far as the stomach-wall of the mosquito. His next observation was that some of the mosquitos, after several days, had scattered through them minute rod-like bodies. On pressing on some of the larger of the sac-like bodies, and thus causing their rupture, he found that innumerable rods of the same kind were liberated, and he concluded, therefore, that the bodies ruptured naturally, and their contents, these rods, were so liberated into the circulation of the mosquito. This the anatomy of an insect would readily permit. Ross showed it was so by pricking the back of a mosquito and examining the minute drop of blood thus obtained. It abounded in the rod-like bodies. In endeavouring to determine the function of these rods Ross came across a gland connected with the proboscis of the mosquito, in which the rods seem specially to collect; and not only did he find them in the gland, which was the salivary gland of the insect, but also in its duct, which opens through the proboscis. This salivary gland forms a fluid which is injected into the skin of the animal on which the mosquito feeds before it begins to suck. It is supposed that this saliva keeps the blood from clotting, and so aids the mosquito in getting a good meal. At all events, it was probable that when a mosquito containing these rods attacked an animal some of the rods were injected at the site of puncture. Ross accordingly allowed mosquitos which had had time to develope these rods to bite sparrows. These in due course developed malaria. Thus was established the proof that mosquitos play the part of an intermediary host for the malarial parasites of birds—in other words, that the mosquito carried the infection from bird to bird.

Ross published his discoveries at once, and forthwith many

corroborative experiments were made in different parts of the world. In Italy work undertaken to show that the same was true of human malaria was equally successful.

Ross had early found that it was not every kind of mosquito in which the malarial parasite could continue its development. It was now a practical question to decide what mosquitos were and what were not responsible for the conveyance of malarial infection. For this purpose a proper classification of mosquitos was necessary, and, curiously enough, the classification of these insects was found singularly deficient and confusing.

The term "mosquito" is itself an indefinite one. It is the diminutive of *mosca,* the Spanish word for fly. Applied by the Spaniards to certain troublesome insects, it was adopted into other languages, and came in time to include not only different species but also different genera. Most of them belong to the gnat family, or *Culecidæ*, and there is indeed very little, if any, difference except in name between many gnats found in temperate regions and mosquitos in tropical countries. I am using the term "mosquito" to-night in its widest sense.

The deficiency in the classification of mosquitos was soon overcome. The whole civilised world was more or less interested, and numerous observers in each country helped in the work. The British Museum authorities issued a pamphlet, "How to collect Mosquitos," and sent it to British officials throughout the world, both in British dominions and at consular agencies elsewhere, at the same time asking that specimens of species found might be forwarded to the Museum. In this way a large mass of valuable material was obtained, which aided materially in the classification and identification of the species responsible for the carriage of malaria.

Many different species were used to repeat Ross's experiment—*i.e.*, that of raising mosquitos from larvæ and letting them feed on malarial blood to see whether the malarial parasite would develope in their stomachs; but the same conclusion was come to all over the world—that it was only among the members of the genus *Anopheles* that this happened. Where human malaria existed *Anopheles* was always found, and, roughly speaking, the distribution of *Anopheles* over the globe corresponded with the distribution of malaria. The knowledge of the actual mosquito concerned being once attained, the experimental research in connection with the prevention of malaria was much facilitated.

There still remained many doubters of the truth of the discovery. In some high places in India ridicule was cast on the idea, and the ordinary lay mind was able to find many

arguments (fallacious ones) against the theory of the implication of mosquitos as agents in the propagation of fever. For this the indefiniteness of the term "mosquito" was in large part responsible. The medical and lay press were inundated with letters, more especially from retired officials, who asserted that they had lived for years in mosquito-infested regions and had not had malaria. These individuals had not taken into consideration the fact that a special mosquito was required. Some asserted that malaria had arisen where no mosquitos were to be found, but in most of these instances a proper investigation led to the finding of *Anopheles*.

The occurrence of cases at sea was brought forward as another argument against the theory, but here the explanation was readily forthcoming. The period of development after the mosquito injects the parasite lasts some twelve to fourteen days, and the period allows the infected individual to travel a long distance. An instance of this occurred on a steamer which, after leaving Calcutta, anchored for a night in the delta of the Ganges. She called only at Colombo, and three or four days after leaving that port there was a general outbreak of ague. The time was about fourteen days from the Ganges, showing, as we now know, that the infection had taken place in that river.

Although the scientific proof of the mosquito theory was complete, something further was needed to impress the fact upon the mass of those living in malarious districts, and perhaps more especially on lay officials responsible for the sanitation of tropical colonies. To do this, experiments of a somewhat sensational character were carried out in several countries. I will refer only to those for which British workers were responsible. One of those experiments consisted in the rearing of *Anopheles* in Rome from the larvæ, and allowing the adult female mosquito thus reared to feed on a malarial patient in a Roman hospital. For the purpose a case of a mild type was chosen. The mosquitos thus fed were forwarded, carefully packed, to London, and allowed to have another meal from voluntary victims—medical men—one of whom was a son of Dr. Manson, the originator of the mosquito theory. These London volunteers in due course developed malaria of the same type as the patient in Rome who had afforded the mosquitos their first meal.

A second experiment was undertaken by some medical men connected with the London School of Tropical Medicine. Their ability to make it was largely due to the Colonial Secretary, Mr. Chamberlain, who appreciated its value in relation to colonial development. The experiment consisted in building a mosquito-proof house specially designed to be suitable for British officials in malarious countries, well ventilated,

but with windows and doors and other openings protected by mosquito-proof netting. This house was erected at Ostia, not far from Rome, at the mouth of the River Tiber, in a district so malarious that any one spending a night there at certain seasons was expected to take malaria. The place was chosen as one of two suggested by Roman observers as having the worst reputations for malaria. The house was inhabited by two medical men and their attendants. By day they went about exploring the country, studying the mosquito life of the district, or amusing themselves. At sundown, however, they went within-doors until after sunrise. The peasants of the neighbourhood considered them mad to come to such a place. Subsequently, when the strangers remained healthy while the peasants were attacked as usual by the fever, the latter came for medical treatment. The experiment lasted for three months (from June to September), and the experimenters remained well during that time. An unexpected addition to the experiment was made during their stay at Ostia. The land on which the house was built was part of a Royal hunting estate, and King Humbert, of Italy, took a considerable interest in the experiment. While it was in progress he was assassinated, and it came to the ears of the authorities in Rome that in Ostia were certain suspicious characters in communication with anarchists. To arrest these, sixteen police officers were sent down from Rome. They spent only part of one night in Ostia, but every one of them about a fortnight later developed malaria.

Similar experiments elsewhere proved equally successful. Dr. Grassi, of Rome, chose another notoriously malarious district, and protected there some of the houses of the railway workmen. Those whose work required their going out at night wore veils and gloves. There were 104 people in these houses. All of them remained free from malaria, although their neighbours, not protected, contracted fever as in other years.

It was thus shown that the individual could under certain circumstances be protected from the mosquito, and so from the malaria; but it was an impossible undertaking to protect all the houses and huts of a country, or keep all the inhabitants within-doors at night. It was desirable to find other means of prevention applicable over larger areas.

The dissemination of malaria theoretically might be stopped either by preventing the infection of the mosquito by man or by preventing the infection of man by the mosquito. The prevention of infection of mosquitos is to be attained by either curing all cases of malaria by the use of quinine or by keeping patients under such conditions that the mosquito could not reach them. In pre-

venting infection of man by the mosquito there are also two courses open—to destroy the mosquitos or protect the man. The possibility of the latter, the protection of the man, we have already shown. The destruction of the mosquito is a very big order, but when its life-history and habits are studied it is seen to be possible within limitations.

Let us for a moment consider the life-history of the mosquito. The great interest aroused by Ross's discovery has made our knowledge of the subject much greater and more exact. Different species have different habits, but there is a great deal common to all. The members of the family *Culecidæ*, to which both *Culex* (the common gnat) and *Anopheles* belong, pass, like other insects, through different stages of existence, presenting in these stages very different appearances and very different modes of life. From the eggs are hatched the larvæ. These inhabit pools of water or the quiet edge of a slowly flowing stream. They feed on minute organisms growing in the water, on vegetable matter, also on each other and on the larvæ of other insects. They require air, and come to the surface to breathe. After a time the larva sheds its outer coat and becomes the pupa, which also lives in the water, but which, unless disturbed, rests quietly at the surface. If disturbed it jerks itself rapidly and forcibly to the bottom. After two or three days the pupa in its turn breaks open its outer skin and the adult mosquito emerges. Hitherto the insect has been aquatic in its habits; but the mosquito, after resting on the pupal skin through which it has broken until its wings are hardened, flies off to the nearest shelter, seeking in the day-time a retired dark spot, but issuing forth at night in search of food. Within a few minutes of sundown it goes abroad, and punctually just before sunrise seeks its hiding-place. (Hence the reason that malaria is contracted mostly at night, and an explanation of the fact that exposure to night air has been for ages regarded as a potent factor in the causation of malaria.) The mosquito feeds on various foods, sucking readily the juices of plants and fruits. It is only the females which are blood-suckers; the male is a vegetable feeder. As a result of observation and experiment, it is believed that the sucking of blood by the female is connected in some way with the proper development of her eggs. Only those mosquitos which have sucked blood produce fertile eggs. After gorging itself the female returns to cover. She does not fly far, and is not carried by the wind, for when the wind is strong the mosquito rests quietly. This fact explains why malaria is contracted often within a very limited area of a district or village. The mosquito does not travel beyond the immediate vicinity of its birthplace. Nor does it fly high in

the air. This fact explains the belief in many malarious countries that huts on high foundations are healthier than those built closer to the ground, and also the salubrity of villages built on hills rising above malarious plains, a well-known fact exemplified by a striking feature in many parts of Italy, where towns and villages are seen on the hills overlooking the level country, where most of the inhabitants ply their vocation as agriculturists.

Even so cursory a description of the life-history of mosquitos suggests several means of getting rid of them. Water exposed to air is required for the life of the larvæ; cover tanks or remove pools by efficient drainage and they cannot exist. A suggested method for use in cases where water cannot be removed, where the mosquitos breed in small lakes or on the banks of rivers, is to spray kerosene over the surface of the water. It spreads out in a film, very thin, but sufficient to prevent the larvæ obtaining air. The larvæ float on the surface with their breathing-tubes above in the air. The kerosene chokes them. The fact that the *Anopheles* lie quiet during the day in the interior of a house or hut enabies them to be killed readily by various vapours. A dwelling can thus be freed from them, and may be kept free by the use of proper netting over doors and windows. These three methods—efficient drainage, the use of kerosene on the surface of pools to destroy the larvæ, and the killing of the adult by insecticide vapours—are the principal means to be depended on in the destruction of mosquitos.

We have noticed that it is possible to prevent the infection of mosquitos by destroying the malarial parasite in the human blood. This is done by the use of quinine. Where, however, the population is large, especially among uncivilised peoples, there are difficulties in the way of its employment. The expense would be greater than any Government could well afford. Moreover, natives do not care to take it—it is too unpleasant for them. Among native races also it is very difficult to decide, without examining the blood, which individuals are malarious and which are not. It has been shown in different parts of the world that many of the hosts of the malarial parasite give no outward sign of being ill. Long-continued exposure to the parasite seems to give an immunity from its most apparent evil effects. The children of native races in malarial districts are almost uniformly affected. This has been shown by the observations of a special German Commission which visited Java, New Guinea, and East Africa. Any one of these children may serve as a centre from which the disease may be carried. Hence it is important that Europeans living or travelling in malarious districts should not have his dwelling or pitch his camp in

the vicinity of a native settlement. He should, if possible, keep at night at a distance from them, and even then should take other measures for prevention of infection.

The destruction of mosquitos, the use of quinine, the protection afforded by the use of netting, are probably none of them by themselves sufficient or possible in a community of any size or over large areas of country. They have proved effective in small communities. One recorded instance is that of a previously very unhealthy island off the coast of Sardinia. Malaria was entirely prevented there during one summer.

Even if in large populous districts entire prevention of the disease is impossible, much can be done by the means we have mentioned to diminish its prevalence, and the more valuable lives may be efficiently protected.

There is no better test of the value of such proposals than their adoption on commercial principles. This has been done in Italy, where legislation has actually been attempted to make employers in malarious districts provide for their employees lodgings and suitable dwellings in which protection is afforded against mosquitos. The Adriatic Railway Company, which used to spend annually £42,000 on hospital treatment and medicine or loss of service through malaria, has determined to attempt prevention by similar means among its workmen. As regards the British Colonial Department, it is making an attempt, more especially on the west coast of Africa, to minimise the occurrence of intermittent fever. The towns have been cleaned out, roads and streets have been drained effectively, the collection of water in pools prevented, articles like old cans or broken bottles in which water might be retained have been removed, netting is provided for the doors and windows of official residences, and the use of quinine by those suffering from ague has been insisted upon. Above all, the natives are being taught that it is possible to avoid the disease by taking proper precautions. It is hoped that in this way the evil reputation of West Africa as "the white man's grave" may soon pass away.

It is easy to forecast that the comparative immunity from malaria thus insured to the explorer and merchant will materially aid in revolutionising the commerce of some parts of the world. The results of the discovery of the cause of the disease will be far-reaching. We have seen how, in the opinion of those able to speak with authority, the control of malaria is the one feature in the condition of tropical Africa which prevents the proper development of trade. We know that it was the lack of such control which prompted Britain to relinquish her

claims to portions of the West African coast, and to permit territory to be occupied by other nations. Fortunately, the interests at stake at other parts of the coast were too great to be sacrificed. We may look forward now to a much greater measure of prosperity and development in that and other lands, development which will affect the whole world by opening up new markets and by increasing the field of production.

The benefits, in the form of life preserved and suffering avoided, it will not be possible to calculate. It is premature to speak of the possibility of the extermination of malaria while so many millions of our fellow-creatures remain beyond the reach of the knowledge of the conditions necessary to prevent it, but among the more enlightened inhabitants of malarious countries the fear of malaria as an unavoidable evil will soon have passed away.

In conclusion, I may refer to a question I have been asked, Is malaria likely to arise in New Zealand? Under present conditions, No. The human host is already here, and from time to time the malarial parasite is introduced by those coming to the colony suffering from ague. There is, however, no *Anopheles*; at any rate, as I am informed by Captain Hutton, none has as yet been discovered in the colony, and until it has been introduced no malaria can arise from infection in the colony. There is no great possibility of both the malarial parasite and *Anopheles* being introduced in such numbers at one time as to occasion a serious epidemic. Now that the Government has arranged a properly organized Department of Public Health, and there is a prospect of this Department in time being equal to the demand made on it, we may say confidently that if malaria is introduced its spread will be easily stopped. That *Anopheles* may be brought here is, however, a possibility, and this becomes greater as our means of communication with Melanesia and the tropical parts of Australia become greater and more speedy. The *Anopheles* might easily be carried on board ship, and so reach our shores. The probability is, however, that if conveyed by ship accidentally from these hot countries it would, on coming into our colder climate, hibernate until the vessel had left our latitude and once more reached a warmer place.

It is interesting to know that Mauritius was formerly free from malaria, but suffered terribly from an epidemic about the year 1867. This epidemic coincided approximately with the discovery in the island of forms of mosquito capable of conveying malaria. This and also the malarial parasite were probably introduced along with coolies from India.

Art. XIX.—*Chips from an Ancient Maori Workshop.*

By Captain G. Mair.

[*Read before the Auckland Institute, 4th August, 1902.*]

Plates LI. and LII.

On the shores of Tauranga Harbour, near Katikati, there used to be a long sandy ridge about 40 ft. above sea-level, covered with such plants as love the seaside. This place was known by the name of Waiorooro (the waters of grinding or rubbing). Struck by the singular inappropriateness of this name, I once asked the late chief Hori Tupaea the reason why it was so called. He said the name had come down from prehistoric times; that it had been the home in bygone ages of a numerous tribe, now long forgotten—the Ngamarama.

About ten years ago, owing to the destruction of the vegetation by fire and the trampling of stock, the sandhill began to move seawards before the fierce and prevailing westerly winds, leaving, in a short time, the original surface of clayey soil, and forming a level sort of plateau some chains wide and perhaps 150 yards long, and disclosing the site of an ancient village with numerous middens and workshops. Around the latter cartloads of obsidian, chert, and different kinds of stone knives and flakes could be seen. Heaps of even-sized round stones for net-sinkers and fishing-sinkers, and hundreds of bone implements made from whalebone, human bone, moa, albatros, and native-dog bones could be seen in every stage of manufacture. Barbed points for fish-hooks or bird-spears also strewed the surface. In fact, here were to be found specimens of almost every domestic article used by a primitive people. Here and there were stone platforms or pavements, consisting of flat stones neatly fitted together and set in some kind of cement, apparently made from ashes or burnt shell. These places were circular, about 6 ft. in diameter, and were probably used for roasting or drying food on. The corner posts (of totara) of many of the houses were still standing, but crumbled to brown dust on being touched. None of the huts appeared to have been more than 8 ft. wide and 10 ft. to 12 ft. long. Stone hammers were also very numerous, and so were stone axes, adzes, gouges, wedges, chisels, drill-points, &c. I gathered over two hundred perfect implements, while probably twice that number of broken ones I discarded. There were also several wooden weapons—paddles, spears, &c.—some showing signs of rough carving; but they fell to pieces on being touched, as did most of the bone articles—hooks, &c.—excepting the uhis or tattooing-adzes and beautiful little

sewing-needles, which, being made from the fine hard bone of the albatros-wing, are in perfect preservation. I also noticed a number of slabs of a kind of sandstone called "hoanga" by the natives, none of which, so far as I know, is to be found in the neighbourhood of Tauranga, and large smooth stones or anvils. The axes, adzes, &c., are also made from a hard kind of stone not found on the mainland, but probably obtained from Tuhua, or Mayor Island, which is just opposite and about fifteen miles off shore. A number of shafts made from bone, stone, or petrified wood were found. They are evidently the haft or stem of some kind of fish-hook, and probably the link is attached as shown in Plate LI., fig. 2.

I found portions of two rare stone pendants or neck ornaments, something like the unique specimen deposited by Miss Morrison in the Auckland Museum. Some years ago I found one exactly similar near Cape Kidnappers, Hawke's Bay.

Only a few greenstone ornaments or greenstone chips were found, and they are probably of much later date. The manner in which the stone weapons are chipped out is really most artistic, and evidences great skill. The class of weapons are evidently the work of a people in a much lower stage of civilisation, and are not highly polished and like those used by the Hawaikians, or ancestors of the present Maoris. Many of the axes and adzes had been fitted with wooden handles, and even the binding of kiekie-roots lay in spirals round the wood and stone, but was quite perished, and the wood crumbled at the lightest touch.

Not the least interesting of my discoveries was finding the tiny model of an ancient *pa tiwatawata*, or palisaded fort, which had evidently been a plaything of the village children. It had been made by sticking three rows of totara splinters into the ground, forming the three lines of defence known as the *Pekerangi*, *Kaikirikiri*, and *Kiri tangata*. There were two gateways (*waharoa*), approached by long alleyways. The model was of this shape, and about 6 ft. by 4 ft. :—

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o . . . . . . . . . .:o   o: . . . . o
o . . . . . . . . . .:o   o: . . . . o
o o o o o o o o o o o o o   o o o o o o
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It is evident that these villagers were a tribe of artisans who made weapons and domestic articles for trading purposes. While they were on a prolonged visit to some other place a gale of extraordinary severity must have overwhelmed their kainga, burying it 20 ft. or 30 ft. deep with drifting sand, and now, after a lapse of perhaps hundreds of years, it has been exposed to view. Since I last visited it the sand has again covered the larger portion of the village-site.

EXPLANATION OF PLATES LI., LII.

Plate LI.

Fig. 1. Haft of fish-hook.
Fig. 2. Fish-hook.
Fig. 3. Fish-hook made of human bone.
Fig. 4. Toothpick made of human bone.
Fig. 5 Sewing-needles made of albatross-bone.
Fig. 6. Stone and shell fish-hooks.
Fig. 7. Bone barbs for bird-spear.
Fig. 8. Mother-of-pearl ornaments.
Fig. 9. Uhi, or tattooing-adzes.
Fig. 10. Spoon made of mother-of-pearl.

Plate LII.

Fig. 1. Bone toggle for fastening tiki ornaments round the neck.
Fig. 2. Curious stone ornament.
Fig. 3. " (side view).
Fig. 4. Bone ornament.
Fig. 5. Stone ornament.
Fig. 6. Portion of jaw of native dog, cut in two.
Fig. 7. Tuatara jaws.
Fig. 8. Shell adze.
Fig. 9. Stone spear-head.
Fig. 10. Moa-bone cut in two.
Fig. 11. Portion of human thigh-bone cut in two.
Fig. 12. Top end of handle, showing carving.
Fig. 13. Poria, or ring for foot of pet kaka.

II.—ZOOLOGY.

Art. XX.—*On some New Species of* Macro-lepidoptera.

By G. V. Hudson, F.E.S.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

Plate XXX.

Caradrinina.

Miselia iota, n. sp. Plate XXX., fig. 3.

The expansion of the wings is a little over 1 in. The fore wings are dull brownish-ochreous finely speckled with black; *there is a conspicuous hook-shaped black mark close to the base,* a sharp black mark on the costa at about $\frac{1}{4}$, a clouded wavy line near the middle of the wing, darker on the costa, a sharp black mark on the costa just beyond this, *followed by a wavy band of dark brownish-black, very much broader on the costa than on the dorsum,* and bordered with a pale wavy line towards the termen. The hind wings are dark brownish-black. The cilia of the fore wings are brownish-ochreous, of the hind wings dark-grey. The head and thorax are brownish-ochreous, and the abdomen grey. There are two conspicuous black marks on the anterior portion of the thorax.

This species is evidently closely allied to *M. pessota,* but is, however, abundantly distinct therefrom. The type specimen was taken at Karori in January, and the species has since been found at Invercargill by Mr. Philpott.

Melanchra umbra, n. sp. Plate XXX., figs. 7, 8, and 9 (varieties).

The expansion of the wings is about $1\frac{5}{8}$ in. The fore wings of the male vary from pale-ochreous to dull reddish-ochreous. The central portion of the wing is more or less clouded with black, and there are often two black patches on the termen below the apex. The orbicular is oval, finely outlined in black; the reniform is large, black towards the base and pale towards the termen; the claviform is obscurely outlined in black; the transverse lines are very faintly indicated, except on the costa. The sides of the thorax are black and the central crest pale-brown. The hind wings are dark

brownish-grey. The female differs in having the fore wings uniform pale-brown tinged with purplish, and the transverse lines are very numerous and distinct.

This fine, though obscurely marked, species was discovered near Invercargill by Messrs. G. Howes and A. Philpott. A number of specimens have been secured, all of which show considerable variation. The perfect insect appears in November and December.

Venusia princeps, n. sp. Plate XXX., fig. 1.

The expansion of the wings is 1¼ in. The fore wings are bright-yellow, with orange-brown markings. There is a shading on the costa near the base; three small obscure spots at about ¼; a rather large spot on the costa at ½, followed by three much smaller spots; there is an irregular somewhat triangular marking at the apex. The hind wings are pale-yellow, with several obscure dots on the dorsum. The head is yellow; the thorax is also yellow, with an anterior band of reddish-brown; and the abdomen is pale-yellow. The antennæ are strongly bipectinated, white, dotted with pale-brown.

This handsome species is described from a single specimen in the collection of the late Mr. R. W. Fereday, which is now deposited in the Christchurch Museum. The exact locality of its capture is unknown.

Notoreas synclinalis, n. sp. Plate XXX., fig. 6.

The expansion of the wings is 1⅛ in. The fore wings have the costa broadly bordered with dark greyish-black; below this there is a longitudinal black streak from the base to a little beyond the middle; next a broad dull-white stripe, followed by a very conspicuous curved black longitudinal stripe, extending from the base of the wing, running parallel to the dorsum towards the termen and curving upwards opposite the tornus towards the apex; on its lower side this stripe is broadly shaded with pale-grey. The lower central portions of the wing are dull yellowish-brown. The hind wings are dark blackish-grey, with an obscure central shading. The cilia of all the wings are dark-grey, obscurely barred with paler grey.

This remarkable-looking species was discovered by Mr. A. Philpott at Seaward Moss, near Invercargill, on the 4th January, 1900.

Dichromodes griseata, n. sp. Plate XXX., fig. 5.

The expansion of the wings is about ¾ in. The fore wings are dark-grey, with paler-grey markings; there is a long stripe running parallel to the costa, and extending from the base

almost to the apex, and a broad, oblique, slightly waved band reaching from the apex to the dorsum at about $\frac{1}{3}$. The hind wings are pale-grey.

This little insect is possibly only a variety of *D. gypsotis*. It was found by Mr. A. Philpott at Seaward Downs in January, 1900.

Selidosema monacha, n. sp. Plate XXX., fig. 4.

The expansion of the wings is nearly $1\frac{1}{3}$ in. The fore wings are shining-white, traversed by numerous jagged transverse lines which are all much broader near the costa. The hind wings are dull-white, obscurely banded with grey. The head and thorax are white, with black markings, and the abdomen is dull-grey.

This very conspicuous insect is described from a single mutilated specimen in the collection of the late Mr. R. W. Fereday, which is now deposited in the Christchurch Museum. The locality of its capture cannot be stated.

Declana glacialis, n. sp. Plate XXX., fig. 2.

The expansion of the wings is about $1\frac{1}{4}$ in. The fore wings are very dark rich reddish-brown; there is a large, very irregular, deeply indented white mark in the middle of the wing extending from the base beyond $\frac{3}{4}$. This marking is almost bisected by a bright reddish-brown longitudinal streak. There is an obscure bluish-grey shading near the termen, and the veins and cilia are bright reddish-brown. The apex of the fore wings is rather prominent and the termen somewhat arched. The hind wings are bright-orange, with several large brown spots on the termen near the apex; the cilia are bright-orange. The head and thorax are orange-brown. There is a conspicuous ochreous band on the prothorax, and the abdomen is dull-orange, speckled with black towards the tip.

In January, 1889, Mr. C. W. Palmer took a single specimen of this fine insect between Gordon's Pyramid and Mount Arthur, at an elevation of about 4,000 ft., in the Nelson District. This specimen he kindly transferred to my collection, but as it was unique and in rather poor condition I did not feel justified in describing it. I was therefore very glad to again meet with the insect during December, 1899, in the neighbourhood of Mount Cook Hermitage, where I was fortunate enough to secure half a dozen very fine specimens. In this locality the moth was observed flying with great rapidity in the hottest sunshine. It was comparatively common at elevations of from 3,000 ft. to 4,000 ft., and frequented the upper portion of the old terminal moraine of the Mueller Glacier, as well as the lower spurs of the Sealey Range.

Art. XXI.—*On some New Species of* Lepidoptera *(Moths) from Southland.*

By Alfred Philpott.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

Plate XXXII.

Melanchra grandiosa, n. sp. Plate XXXII., fig. 1.

♀, 44 mm. Antennæ and legs brownish-ochreous. Palpi brown, terminal joint ochreous. Face greyish. Thorax bright orange-brown, between patagia brownish-yellow; slight anterior and strong double posterior crest. Abdomen dull-brownish, anal segment tipped with pale-yellow. Fore wings slightly sinuate on costa, apex subacute, termen crenulate, purplish-brown, base suffused with ochreous. An indistinct pale irregular line near base; a small elongate yellow spot above middle at about $\frac{1}{5}$; an ochreous patch below middle from base to $\frac{1}{5}$; below this a broad elbowed black line to $\frac{1}{4}$; dorsum broadly suffused with pale-ochreous; an irregular V-shaped pale purplish-brown line from near costa at about $\frac{1}{4}$, shortly bent towards base, thence obliquely to near dorsum at $\frac{1}{2}$, again slanting upwards to reniform; space within V-shaped line much darker. Near centre of wing, above middle, a large bell-shaped ochreous blotch, the base towards costa. Reniform faintly outlined in pale purplish-grey. A sharply defined oblique line from costa near apex to dorsum at $\frac{4}{5}$, dentate near apex and broadly projecting below middle; beyond this line the colour is ochreous-brownish densely irrorated with dark-brown. A waved subterminal line. Cilia brownish-ochreous on termen, pale-ochreous on dorsum. Hind wings dull brownish; cilia brown, greyish towards tornus.

Perhaps the most handsome New Zealand species of the genus yet described. It is not likely to be confused with any other form.

West Plains. Taken at "sugar" in May. Mr. George Howes, of Invercargill, secured a male at about the same time, but, as it was not in very good condition and differs very little from the female, I have described from the latter sex.

Melanchra exquisita, n. sp. Plate XXXII., fig. 2.

♂, 32 mm. Head and palpi greenish; tips of palpi and outward surfaces blackish; two linear black marks on crown of head. Antennæ brownish, shortly bipectinated. Legs

greenish, annulated with black. Thorax with moderate bifid anterior and posterior crest; green, with black irregular V-shaped mark, the apex towards head. Abdomen dull-yellowish, anal segments black; also blackish on sides of segments, and dorsal series of black spots. Fore wings: Costa almost straight, apex rounded; termen not crenulate, obliquely rounded, bright-green, black suffusion from base obliquely towards dorsum, terminating in oblique black white-margined upwardly bent projection at $\frac{1}{4}$; distinct white irregularly black-margined line from costa near base to black suffusion, irregular interrupted white-margined black line from about $\frac{1}{4}$ of costa to before $\frac{1}{2}$ of dorsum, several irregular projections at middle of wing, and upper half of line forked; irregular black outwardly white-margined band at $\frac{1}{2}$, outwardly oblique to middle of wing, thence inwardly oblique to dorsum, on which broadly and irregularly clavate; costa with alternate black and white dots; reniform spot obscurely outlined in black, edged with white; dentate black line beyond reniform, indentations filled with white; strong subterminal black line, interrupted above and below middle, broadly and suffusedly white-margined. Cilia green, barred with black, and with an indistinct darker line. Hind wings pale greenish-yellow, with brownish suffusion on apical portion; an irregular line at $\frac{2}{3}$, and discal spot of same colour. Cilia pale-green.

Very handsome and distinct.

West Plains, at "sugar," in December.

Tatosoma topea, n. sp. Plate XXXII., figs. 3 and 4, ♂ and ♀.

♂, ♀, 28 mm. Head and thorax dull-greenish, with many black scales. Antennæ greenish-brown. Legs yellowish-grey, anterior pair annulated with dark-brown. Abdomen grey, with segmental divisions marked with dark rings. Fore wings dull-green, thickly sprinkled with black and white scales. A reddish suffusion occurs in most examples; in some barely a trace is discernible, while in others the greater part of the wing is so coloured. Veins outlined in black, in most specimens interrupted with linear white spots; a broad white fascia from costa at $\frac{3}{5}$, obliquely towards dorsum for short distance, then abruptly bent towards termen; an indistinct double waved dark subterminal line. Cilia brownish. Hind wings cinereous. Cilia paler.

The female differs in having a distinct, almost straight, double dark line from costa at $\frac{3}{5}$ to dorsum at $\frac{2}{5}$. The white costal fascia is not so distinct.

Easily distinguished from the other species of *Tatosoma* by its smaller size and the white costal fascia.

West Plains. Fairly common during November and December at flowers of the white rata (*M. scandens*).

Xanthorrhoe occulta, n. sp. Plate XXXII., fig. 5.

♂, 28 mm. Head and thorax dull yellowish-brown. Legs and abdomen paler. Antennæ shortly bipectinated. Fore wings dull yellowish-brown, sometimes with reddish tinge, more pronounced near base; a white dot posteriorly black-margined on vein 1 at $\frac{1}{3}$; a similar dot near origin of vein 2; a chain of similar dots, black-margined anteriorly, from $\frac{3}{4}$ costa to $\frac{3}{4}$ dorsum. Cilia reddish-brown. Hind wings very pale whitish-yellow. Cilia same colour.

My three specimens are all males. I have a moth which is probably the female of this species; it differs in having the fore wings bright ochreous-brown. The cilia of the hind wings are also ochreous-brown.

This species differs from *X. ægrota*, which it resembles most, in the shorter pectinations of the antennæ and the presence of the subterminal chain of white spots.

West Plains, October and November, at light.

Xanthorrhoe oraria, n. sp. Plate XXXII., fig. 6.

♂, 20–25 mm. Whole insect pale dull-yellow. In some examples indications of a dark line across fore wings at $\frac{1}{3}$, and a more pronounced irregular thin line at $\frac{2}{3}$, beyond which the colour is paler, but very few specimens have even these markings. All specimens have, however, a dark spot near costa, before $\frac{1}{2}$.

An obscure and dull-looking species differing from other species of the genus in the almost total absence of markings. I found the male plentiful during November at New River amongst the tussock-grass on the sandhills, but have not yet met with the female.

Selidosema fascialata, n. sp. Plate XXXII., fig. 7.

♂, ♀, 35–38 mm. Head and thorax dull-brownish. Abdomen pale-yellow. Fore wings rich dark-brown irrorated with darker; a yellowish-white convex band at $\frac{1}{4}$, anteriorly somewhat suffused; space from $\frac{1}{4}$ to $\frac{2}{3}$ occupied by a broad blackish-brown band, posteriorly deeply indented above middle, and broadly margined with an irregular yellowish-white suffusion; a subterminal serrate white line, interrupted in middle, broadly and irregularly margined with blackish-brown; a subapical triangular patch margined below with blackish-brown; a row of minute black spots on termen. Hind wings yellow, with a few scattered dark scales, and sometimes a row of black dots on termen.

The female is rather paler in colour, but otherwise does not differ.

From *productata*, its nearest ally, this species differs in its more pronounced markings and the deep indentation in the posterior margin of the median band. While hardly two specimens of *productata* are alike, examples of this species, except in depth of colouring, exhibit no variation.

West Plains, Haldane, Clifton, and probably throughout Southland. During February and March, at flowers of ragwort (*S. crucifolius*).

ART. XXII.—*On* Charagia virescens, *Dbld.*

By AMBROSE QUAIL, F.E.S.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

Plate XXVIII.

THE species which forms the subject of this paper is the largest New Zealand Hepialid, a very handsome species, expanding in the imago stage from 3½ in. to nearly 6 in. It has from time to time been described under the generic title of either *Charagia* or *Hepialus*, the latter being adopted by Mr. E. Meyrick and by Mr. G. V. Hudson. I, however, would urge the acceptance of Walker's name *Charagia* for *virescens* and its Australasian allies, not in the generic sense, but as a subgenus of *Hepialus*.

The larvæ of true *Hepialus*, the type of which is *humuli*, Linne, are subterranean root-feeders, perhaps sometimes phytophagous, never lignivorous. The species are found in Europe and Asia—excepting one, so far as I know undescribed and therefore doubtful, from Guatemala—and nowhere else.

Three subgenera of *Hepialus* occur elsewhere—*Phymatopus*, Wallgr. (Europe, North America); *Sthenopis*, Pack. (North America); *Cibyra*, Walk. (Europe, Asia, South America).

The species which may be referred to *Charagia* are wholly Australasian, the larvæ lignivorous, feeding in vertical burrows, no doubt an important item of their pabulum being the sap of the tree. Geographical distribution, supported by the habits of the larvæ, warrants the title *Charagia*, despite the fact that no definite structural difference can be found between *Charagia* species and *Hepialus* species. It appears to be a more natural indication of affinity to associate

them thus than to arrange *humuli*, followed by wood-borers, and again by subterranean feeders, as is done, I believe, in the British Museum collection.

Hepialidæ appear to be remarkably uniform in the ovum stage; the size of the ovum varies between species, being smaller or larger by comparison. *C. virescens* ova are rather large; but all are smooth and spherical, and when extruded are yellowish or whitish, and afterwards turn black in colour. All the species of various genera of *Hepialidæ* of which I have knowledge agree in this respect.

No descriptions have as yet been published of newly hatched *Charagia* larvæ. I very much desire to obtain fertile ova for this purpose, having always failed hitherto, and the newly hatched stage is calculated to furnish evidence of affinity of greater value than the adult larva.

Mr. R. Illidge and myself have examined larvæ at a more advanced stage of several species, and there is remarkable uniformity—I may say almost identity—of structure between Australasian *Charagia* and *virescens* of New Zealand, which have abundant specific distinction in the imago stage. It is not necessary to detail the larval structure of *Charagia*, this having been done in our paper on Australasian wood-boring *Hepialidæ*,* but for the purpose of this paper a note may be made that the prothorax has an anterior dorsal series of equidistant setæ, a mid-lateral scutellar concavity enclosing in *virescens* three setæ when young, one only in adult larvæ, with always a single seta below the concavity; spiracle enlarged and posterior; a lower anterior tubercle bears two setæ. The abdominal segments have normal single-seta trapezoidal tubercles; supraspiracular tubercle has two setæ; spiracle anterior; two subspiracular single-seta tubercles a little below posterior almost in line with each other; an anterior single-seta tubercle; and four setæ on base of the abdominal feet. Of these the prothoracic scutellar concavity appears to be peculiar to *Charagia*, the other features being more or less typical of all *Hepialidæ*.

Mr. Hudson mentions† that young larvæ (how young?) are olive-green in colour. I have examined many larvæ from about ¾ in. in length without seeing this form, all being normal in colour and practically so in structure with more adult larvæ—*i.e.*, yellowish or reddish. Amongst others, I once took a larva about 1¼ in. in length which differed remarkably from the normal—an undoubted Hepialid from tubercle structure, a *Charagia* from prothoracic scutellar concavity, and almost certainly *virescens*, since this is the

* Proc. Roy. Soc. Queensland, 1900.
† "New Zealand Macro-lepidoptera."

only species in New Zealand. The larva appeared to be marked by alternate brown and yellow transverse dorsal lines, with lateral and ventral brown spots, closer examination showing the elevated portions of segments, subsegments, and tubercle areas to be brown, hard, and polished (chitinous ?), the incisions and ground-colour being yellow. The thoracic segments did not differ so from the normal. This larva, maybe, had retained its juvenile characteristics until a later stage than usual, or it is, perhaps, an exceptional form. In either case it is of considerable interest that a form of *Charagia* should occur having dorsal and lateral shields on the abdominal segments. Typical *Charagia* have only the prothoracic scutellum hard, the remaining segments being fleshy on the dorsal area.

In an account of this species it would be unwise not to mention the curious fungus, known commonly as the "vegetable caterpillar" (*Cordyceps hugelii*, Corda; *Torruba robertsii*, Hook.), which has been so commonly associated with the larva of *C. virescens*. I have examined specimens which retain the tubercles fairly well, and find the arrangement to be that of the *Hepialidæ* so far as it can be made out. I agree, however, with Mr. Meyrick—and believe Mr. Hudson has somewhere given the same opinion—that the larva is not *C. virescens*, which does not leave the larval burrows until emerging as an imago. As far as I know, the host has never been identified; being subterranean, it is probably of the *Porinæ*.

The larva of *C. virescens*, when full fed, retires to a vertical burrow, which it seals up transversely with a silken operculum at the entrance. It is not correct, I think, to term this operculum a "trap-door," as I and others have done. The latter name suggests a definite hinged cover, whereas I do not think this to be the case. When the imago has emerged the operculum frequently remains attached at some point to the rim of the burrow. This is not invariably so, but when so attached it is always on that side farthest from the passage used by the pupa, otherwise the operculum might prevent egress. However, this is not an argument in favour of the belief in the trap-door, as the larva might easily provide for contingencies by making the one side weaker than the other at the suture of the operculum and the rim. As a matter of observation and examination, I believe the operculum of this species and *C. daphnandræ*, which makes a similar prepupal operculum transverse to the burrow, is not hinged. *C. eximia*, another Australian species, makes its prepupal cover inner to the external cover, therefore vertical, not horizontal. Incidentally, which is the more ancient method?

The passage from the larval burrow to the outer chamber is effected by the pupa, which removes the operculum, and, I believe, the external cover also, but this I have not been able to verify by actual observation. An imago had failed to emerge from one pupa which I took from an outer chamber, the *external cover being already removed.* Here is an interesting problem: the external cover is usually demolished with considerable completeness, but the pupa, remaining as it does with the anal segments within the larval burrow, could not in many cases reach the external cover to remove it and permit free egress of the imago.

Examination of the pupa may here help us. The head, prothorax, and mesothorax dorsally are hard, longitudinally but finely corrugated on the head and mesothorax, irregularly so on the post-thorax, which is smooth posteriorly. Undoubtedly this is a protection to that portion of the contained imago, and would resist tremendous pressure. One would think the pupa requires less, not more, protection than the larva, which has done all the boring, and in its later days, having no more to do, it loses the dorsal hard area (scutellum), becoming more fleshy.

It seems that the removal of the operculum, and likewise the external cover, is due to aerial pressure from within, initiated by movement of the pupa—in fact, literally blown off. It must be remembered that the pupa is located at the lower end of the vertical burrow until the time of emergence. The pupa in bulk approximates very closely to the circumference of the burrow, and the segmental spines give it great power in forcing its way upward. The anterior portion of the pupa would necessarily need to resist great pressure, which, as we have seen, is possible by the corresponding greater strength of that portion. The pupa does not appear to expand when making its escape from the burrows.

I have for several years taken annually a fair number of imagines, both males and females, from the trunks of *Hoheria populnea*, Cunn., where they may be found drying their wings an hour or so before dark during the month of September in this district. The females are very variable, males more constant, the species being sexually dimorphic as regards wing shape and markings.

The males vary as regards the size of the typical white spots of the fore wings, and in having occasional additional ones, but always have faint pale-green ring-like markings also. Unlike the majority of its sex, one male which I have taken has all those usually pale-green markings of the fore wings distinctly and decidedly white in colour. I propose for this aberration the name "*albo-extremus.*" It must be very rare, as I never saw but the one specimen—which, indeed, I am now

sending to my valued correspondent Mr. Roland Illidge, of Brisbane, in recognition of the very great assistance he has from time to time rendered me in my studies of the Hepialid group of *Lepidoptera*.

The females vary as regards the dark markings. On the green ground-colour there are outlined a series of spots which in the male are white, also an outer series, and there are constantly dark costal markings. Numerous pale-green elongate markings are on the wing-surface generally, these likewise in some specimens being outlined with dark-fuscous. A not uncommon form has the green ground-colour entirely replaced with a dark colour which may be rather rusty in hue, with the fine lines and markings green in colour but blurred in outline, or, as in the figure, very distinctly approaching black, with numerous transverse lines and spots clearly defined in green. The latter form appears to be that described by Butler* as *Charagia hectori*. If it is permissible to use as a varietal nomen a name which was originally applied in the specific sense, I should like to see this distinct and handsome form of the female recognised as ab *hectori*, Butl.

It does seem important that varietal forms of *Lepidoptera* should be distinguished by names, the comparative rarity or otherwise of which may then be placed on record with who knows what valuable result to science in after-years in a country like New Zealand, when the local fauna becomes, as it undoubtedly must, more or less modified by altered environment brought about by the agency of man, the effects of which may be better observed in a comparatively small area than in large continental areas.

May we speculate on what was the primitive stock from which *C. virescens* was derived—*i.e.*, *Charagia* or *Hepialus*? There is little doubt the colour was green, the white of the male and dark female markings being more recently acquired. This is found in the greater permanence of the green coloration as compared with the other less constant colours. Everywhere in the *Hepialidæ* we find white is a varietal colour; indeed, in *Hepialus humuli* the male is uniformly white on the upper surface of both wings. The original form, resembling the female coloration and markings, still exists in the Shetland Islands, being known as "var. *hethlandica*."

The Queensland species, *C. daphnandræ*, is just such a species as might have been ancestral to *C. virescens*; the coloration of both sexes is the same, being green, with scarcely any wing-markings. Several Australian *Charagia* have silvery spots on the fore wings, amongst these being *C. eximia*. We can safely place the white-spotted *C. virescens*

* Proc. Zool. Soc. Lond., 1877.

as intermediate between *C. daphnandræ* and these latter species; the further similarity in larval habits indicates very close relationship, if not actual descent, of *C. virescens* from the Queensland species *C. daphnandræ*.

Further Notes.

Hitherto my friend Mr. Blackmore Lane has accompanied me at the proper season to search for *C. virescens* on the Hokowhitu property of Mr. James Ritchie, near the banks of the Manawatu River, where *Hoheria populnea* (thousand-jacket tree) grows in fair quantity; it was possible, however, to get there only at intervals of sometimes a week. This season, in addition to our joint visits, Mr. Ritchie made constant and almost daily search at dusk, and when successful brought his captures to me to prepare and set, and a larger number than ever before have passed through my hands.

The first specimen, a female, was taken at light on the 6th September, it having already deposited all excepting one of its ova, and that proved infertile. The weather being cold, it was not until the 19th September that others were taken, although repeated search was made. Subsequently the equinoctial gales were accompanied by frost, and none were seen until the 29th September; from this date they were taken with more and more frequency, sometimes one or two specimens only, sometimes many, until early in November.

At first, and during the prevalence of a rigorous atmosphere, a considerable number of crippled specimens were found, whereas in previous seasons, with more genial temperature, it has been exceptional to find any such; and to the same cause we have no hesitation in referring buff-coloured specimens (mentioned by Mr. Hudson in his work on *Macro-lepidoptera*), of which three males were taken on the 29th September, one being crippled. Two females of this form were taken at a later date.

We have not met with this aberration until the present season, but that it is due to atmospheric conditions acting on the developing imago in the pupa stage is strongly suggested by a curious specimen having its superior wings symmetrically streaked with golden buff on the usual green ground-colour. If atmospheric influence acted directly on the imago at the time of emergence one would expect the wings to be asymmetrically streaked. Is this coloration due to retarded emergence, and consequent alteration in the strength or nature of the pigment in the wing-scales?

Other notable specimens were one *albo-extremus* taken on the 29th September, and three other *albo-extremus* on the 15th October. Male specimens were the most plentiful.

Mr. Ritchie, however, believes this is due to the females frequently emerging later—*i.e.*, after dark—and this opinion was supported by finding quite a number of freshly emerged females after dark on one occasion, there being no males observed at the same time. Two females have a white blotch agreeing with the white blotch frequently observed at lower part of the band on male specimens. More than one female specimen have dark "chocolate" spots about one-third from tips of superior wings, these being remarkably reminiscent of *C. daphnandræ*.

The colour of *Charagia virescens* suggests protective resemblance; that it is really so I have little doubt. Mr. Ritchie one evening drew my attention to what he thought was a male specimen—which, in my opinion, was probably a female specimen—perched some 15 ft. up on a tree-trunk. It was getting dark, and objects at that distance in the shade amongst branches could not be clearly distinguished. With a long stick it was reached down, and proved to be a leaf split in the middle. Doubtless a sharp-eyed morepork often passes a specimen under the impression that it is a leaf.

One curious fact may be mentioned: ova of *C. virescens* are normally pale-yellow when first laid, becoming black after several hours. On several occasions this season black ova were extruded among the pale-coloured ones by freshly emerged females; and, moreover, *within* the abdomen of several specimens black ova were mixed amongst the others.

To observe if possible the manner of emergence from the vertical bore and through the operculum we obtained some pupæ. Having cut the wood so as to divide the bore between the operculum and the pupa, on every occasion that the top half was removed the pupa would slide up to investigate the cause of the disturbance in the atmosphere above. On touching a finger held above it the pupa would immediately descend again, apparently satisfied that all was right. This was repeated with different pupæ, proving that *C. virescens* can and does travel up and down its vertical burrow at will during the pupa stage. I now believe the operculum is cut or removed by pressure of the pupal headpiece, and not by aerial pressure, as I was previously inclined to think. One thing is certain, the cover is not a trap-door, in the sense of being hinged, until after emergence of the pupa.

EXPLANATION OF PLATE XXVIII.

Fig. 1. Prothorax of unusual form, larva of *Charagia virescens*; magnified.
Fig. 2. Abdominal segment of ditto, dorsal aspect; magnified.
Fig. 3. " lateral aspect; magnified.
Fig. 4. Anterior segments of pupa, *C. virescens*; natural size.
Fig. 5. *C. virescens*, male, nov. ab *albo-extremus*; natural size.
Fig. 6. " female, ab *hectori*, Butl.; natural size.

Art. XXIII.—*A Fly and a Spider* (Pompilidæ, Salius monachus, *Sm.;* and Porrhothele antipodiana).

By Ambrose Quail, F.E.S.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

Plate XXIX.

It is proverbial that spiders are cunning and ferocious, and it is popularly supposed that their physical strength surpasses the strength of flies, yet just as flies are helpless under a spider's bondage, so, literally speaking, in the hands of some flies are spiders helpless.

To begin with, a class of flies having four wings, a sting, and which construct a nest wherein they deposit eggs and their young afterwards mature, are known to naturalists as *Hymenoptera Aculeata.* Examples of this class are the bees and wasps. In my young days I derived amusement from the antipathy that spiders have for flies of this class. A strong cunning spider will lie low and concealed when some one or other of these four-winged flies happens to be in its vicinity. Put a wasp in the web of a spider—one of the *Epeira* group—and watch results. (The species on which I used to experiment was *E. diadema.*) The spider almost invariably would be most anxious to be relieved of her visitor, to effect which she will frequently sacrifice part, often a large part, of her laboriously constructed web. In feverish haste, keeping all the time well out of reach, the spider severs the strands above its captive, the weight of the insect breaking away the lower strands.

I question much whether *E. diadema* gained knowledge of the formidable character of its captive from actual individual experience; certainly they fear the consequences of coming to close quarters. Is the antipathy instinctive? Can it be that generations of spiders have witnessed the hapless fate of their neighbours when some four-winged Hymenopteron, descending from above, like an eagle upon a lamb, has carried away a spider captive, to incarcerate her in a cell or mud-hole, paralysed and helpless, doomed to form the fresh meat on which the young of its captor will feed and mature?

The advantage possessed by the fly is in the powerfully poisonous secretion which it injects by means of its sting into some portion of its victim's anatomy, with instantaneous paralysing effect. Peckham,* having broken off the leg of a small crayfish, induced a wasp to sting it at the exposed part

* "Instincts and Habits of the Solitary Wasps."

of the stump; immediate paralysis ensued, and a few hours afterwards the crayfish was dead.

Naturalists are divided in opinion as to whether the fly purposely paralyses its captive without killing in order that the meat shall remain fresh until the eggs deposited in the same nest have hatched, or whether paralysis is a fortuitous result.

When collecting other insects I have not unfrequently noticed the *Pompilidæ* foraging for spiders; but a recent case was particularly striking in the remarkable disparity in size between the fly and its captive.

At a place where the bank at the side of a road had fallen I noticed, when driving by, what appeared to be a large black insect fluttering down, now stopping on a small ledge, now descending until it nearly reached the bottom. Investigation showed that a fly (*Salius monachus*)* had captured a great hairy spider (*Porrhothele antipodiana*),* whose weight was so great as to drag the fly down the steep bank. When I reached them the fly was some distance away, apparently searching for a suitable hole in which to bury the spider. It soon returned, and, taking firm hold with its fore feet, commenced to drag the body along with comparative ease, the fly walking backwards. A comparison can be made by imagining a man, single-handed, dragging the body of a large full-grown dray-horse. The fly would not leave its captive, and I had no difficulty in getting both into one of my boxes.

At home I examined the spider, and unhesitatingly declared it to be dead. The legs were limp, and so expanded as to look as though it had attempted to run when attacked. The pair of posterior appendages were also relaxed, and extended horizontally. There was no alteration in the condition of the spider for twenty-four hours, but after that interval the spider showed evidence of life in having drawn its legs into a crouching posture, and the anal appendages were elevated vertically. In a day or two the spider, if irritated, would move its legs slightly; but the anal appendages at all times showed more sensitiveness. Exactly seven days after the date of its capture the legs and anal appendages were again relaxed, and it was dead indeed.

Against this fly the spider could have no chance, the whole of the former presenting a smooth, hard surface. It is, indeed, a regular Ned Kelly of the insect world, and quite without vulnerable spots. Had the fly not been interfered with it would certainly have buried the spider, which would have revived, and most probably, before it died, would have had the young of its captor gnawing at its vital parts, it being meanwhile unable to resist—a fearful fate indeed.

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* Identified by Captain F. W. Hutton, F.R.S.

Kirby, quoting Consul Krug, says of a large West Indian Hymenopteron (*Scolia atrata*) that it digs its nest, "then goes in search of a grasshopper. Having partially disabled i with its sting, it mounts on its back and rides it up to its own grave, where it buries it. If the grave proves to be too small, the wasp drives the grasshopper away while it enlarges it as much as is required, and then brings the grasshopper back to the hole."

There is a great deal of interest in the life around us, of which we know very little.

EXPLANATION OF PLATE XXIX.

Fig. 1. *Porrothele antipodiana.*
Fig. 2. *Salius monachus.*
Both natural size.

Art. XXIV.—*On the Anatomy of* Paryphanta busbyi, *Gray.*

By R. Murdoch.

[*Read before the Wellington Philosophical Society, 16th December, 1902.*]

Plate XXVII.

An example of this fine species preserved in alcohol recently came into my possession. Unfortunately, the animal was completely retracted within the shell and very hard, an unsatisfactory condition for anatomical investigation. In order to extract the animal it was necessary to sacrifice the shell. The retractor muscle encircled the columella to the extent of a complete volution; the muscular impression is somewhat acutely ovate, and the position of its upper margin is about one and a half whorls from the apex of the shell. Above this, and proceeding towards the apical whorl, there is an ill-defined narrow muscular scar. This was doubtless the seat of the retractor muscle in the young animal, but in the adult form I do not think there is any muscular attachment outside of the area defined by the great impression.

The animal is bluish-black, with the foot-sole perhaps a shade lighter in colour. On the head and neck are a few regular rows of rugæ, somewhat quadrate in outline; on other parts of the body the rugæ appear to be oval-shaped, irregular in size, and not forming continuous rows.* The mantle has a sharp even margin, and a deeply incised line or groove rather

* For a figure of the animal, see Proc. Linn. Soc. N.S.W. (2), vol. ii., pl. xx., fig. 6.

less than 2 mm. from the edge. On the underside of the mantle is the usual prominent lappet which conceals the respiratory and anal pores, and in addition to this is a long narrow fold on the left side.

The buccal mass (fig. 1) is enormous in size and muscular development. Its posterior end is curved down and forward, and a powerful ventral muscle firmly binds it to the more anterior cylindrical portion. The retractor muscle (*r. m.*) envelopes the posterior end, and from the anterior portion of the mass proceed a number of ventro-lateral muscles (*ant. r. m.*), which unite with the immediately adjoining body-walls. The œsophagus (*œs.*) enters the buccal cavity dorsally in the anterior fourth. The salivary glands (*s. g.*) are situate upon the posterior half of the buccal mass; they are fused together in the median line and partly envelope the œsophagus. From the anterior end of each gland proceeds a small salivary duct (*s. d.*), which enters the buccal cavity a little below the œsophageal opening. The stomach (*st.*) forms a simple elongated sac, and the tract of the intestine does not appear to differ from *P. hochstetteri*, Pfr.

The teeth have been described and figured by Captain Hutton;* the formula given is 50–0–50. In the specimen under investigation many of the rows of teeth give the formula 52–0–52. A few of the innermost teeth (fig. 2), usually not more than two on each side, are small and very slender. Occasionally one of these slender spicula-like teeth is somewhat separated from the adjoining teeth, and where this occurs it gives to the row the appearance of a central tooth. Fig. 3 represents the teeth 20 to 26 in one of the rows.

The kidney is shortly tongue-shaped, in length less than twice its breadth, about half the length of the lung, and about one and a half times the length of the pericardium; the latter has the usual position on the left margin of the kidney. The ureter continues around the right margin of the kidney, follows the posterior limit of the lung, and opens close to the intestine. From this point the intestine, or rectum, forms a long straight tube. There is a well-marked ridge on the pulmonary wall less than 3 mm. from the side of the rectum, and the narrow area thus defined appears to be the open continuation of the ureter. The above-mentioned ridge examined in section proves to be tubular; it continues into the tissue of the mantle, and appears to unite with the blood-sinus contained therein. The venation of the lung, with the exception of the great pulmonary vein, is very indistinct. This vein runs direct to the auricle, is of considerable breadth, and has an undulating, almost convolute, appearance. On approaching the

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* Trans. N.Z. Inst., vol. xiv., p. 153, pl. iv., figs. A, L.

pneumostome it forms several branches, and the latter, with their accompanying afferent vessels, are fairly well indicated. The vessels on the rectal side of the lung are minute and very much branched, while on the cardiac side only a few traces may be seen.

The pedal gland opens between the head and foot immediately below the mouth; it forms a long flattish structure, much folded and lying on the floor of the body cavity. Its posterior end is slightly enlarged, and enclosed in a cavity in the foot, to which it has a muscular attachment. From the termination of the gland the usual tube or duct proceeds through the substance of the foot, but does not form a caudal mucous pore.

The retractor muscles: The buccal mass and pedal retractors are fused together posteriorly where they unite with the columella of the shell. The buccal retractor rests dorsally on the pedal muscles, and forms a broad powerful band. The pedal retractors are continuously attached to the foot, and there are no free progressively attached pedal retractors as in *Helix*. The ocular retractors branch from the pedal muscles; they bifurcate towards their anterior ends, and supply the inferior tentacle retractors.

The genital system is particularly interesting, and differs from the three anatomically known species—viz., *P. hochstetteri*, Pfr.,* *P. edwardi*, Suter,† and *P. unmula*, Pfr.,‡ in the extreme reduction of the male organs and the absence of a receptaculum seminis; but, when compared with the genital organs of *Schizoglossa novoseelandica*, Pfr.,§ a slug-like animal, there is a most remarkable resemblance. Fig. 4 gives a general outline of the genitalia.

There is a blunt, somewhat triangular, projection of the vaginal wall, with a retractor muscle proceeding to the adjoining body-wall; this is the only evidence of the male organs before any of the surrounding tissue has been dissected away. On removing this outer tissue a small loop is seen to project from the vaginal wall (fig. 5, *p.*). This I regard as the posterior termination of the penis, which passes into the vas deferens without any perceptible change, except a slight diminution of the tube. To follow the course

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* Godwin-Austen, Proc. Malac. Soc. London, vol. i., pp. 5–9, pl. i. (by an evident slip of the pen this plate is made to appear as illustrating the anatomy of *P. busbyi*); Collinge, Ann. Mag. N.H., ser. 7, vol. vii., pp. 68–70, pl. ii., figs. 17–21; Beutler, Zool. Jahrb. (Abth. f. Morph.), 1901, bd. 14, pp. 369–416, t. 26–29.

† Collinge, *ibid.*, pp. 70–71, pl. ii., figs. 22–25.

‡ A note on the anatomy of this species has been forwarded to the Malac. Soc. London, but the publication has not yet reached me.

§ Hedley, Proc. Linn. Soc. N.S.W. (series 2), vol. vii., pp. 387–392, pls. ix.–x.; Collinge, *ibid.*, pp. 71–72, pl. ii., figs. 26–30.

of these organs sectional investigation is necessary, and fig. 5 has in part been constructed from the data thus obtained. The anterior portion of the vagina (*ant. vg.*) forms a wide chamber, closed posteriorly by a valve-like papillar structure (*vg. p.*); the interior walls are slightly darkish in colour, and weakly longitudinally plicated. The papilla is continuously united with the vaginal wall, and the perforation through its centre is the only communication with the oviduct. Its anterior third projects freely into the anterior vaginal chamber. Its walls are comparatively thick; internally they are lightly longitudinally plicated, and have a whitish epitheloid lining.

The penis (*p.*) opens into the posterior portion of the papillar structure in the form of a small tube; it proceeds through the thick vaginal wall in an oblique anterior direction, and becomes slightly enlarged or bulbous towards its termination. The vas deferens (*v. d.*), as previously stated, is free to a very limited extent, and is imbedded in the vaginal wall. Its posterior prostatic course through the prominent folds or plications of the oviduct is tubular to a little above the position of section *b*, thence open, but for a short distance enfolded on all sides by the above-mentioned plications as figured in section *c*. From this point to the albumen gland it is a well-marked area of a rusty brownish tint, and somewhat separated from the uteral portion by the longitudinal folds. The uterus (*ut.*) is thrown into numerous sacculations, and its interior walls are richly convolutely plicated. There is no indication of a receptaculum seminis. The albumen gland (*alb. g.*) is very large, a usual feature in this group of animals; in outline it is roughly boot-shaped. The hermaphrodite duct (*h. d.*) enters near the base of the albumen gland; it is a simple straight tube, with several short lesser tubes branching from it and uniting with the several masses which form the hermaphrodite gland. The latter (*h. g.*) are closely convoluted structures and imbedded in the liver.

When compared with *Schizoglossa novoseelandica* it is found that the vas deferens in the latter species is free to a greater extent, that no portion of its internal prostatic course appears to be tubular, and there does not appear to be any vaginal papilla. During copulation the atrium is everted; the penis pore is thus brought forward and may be detected on the everted wall. In *P. busbyi* what I have termed the anterior vaginal chamber doubtless undergoes complete eversion, and the vaginal papilla will be thrust outwards to a considerable degree—probably to a much greater extent than the appearance of the organ in its present condition suggests. The generative organs of the three previously mentioned species differ from each other in a rather marked degree, and the type of the genus further accentuates the divergence.

There yet remain two rare species which are anatomically unknown—viz., *P. gilliesi*, Smith, and *P. lignaria*, Hutton. A knowledge of the anatomy of these species is much to be desired, and I trust the collector who may have the good fortune to secure them will not neglect to preserve the animals.

In the allied genus *Rhytida* the teeth of the majority of the species have been described and figured, but, with the exception of two species, *R. greenwoodi*, Gray,* and *R. meesoni*, Suter,† nothing is known of their general anatomy.

EXPLANATION OF PLATE XXVII.

Paryphanta busbyi, Gray.

Fig. 1. Buccal mass, salivary glands, and portion of the alimentary canal.
Fig. 2. } Teeth.
Fig. 3. }
Fig. 4. Generative organs.
Fig. 5. Sectional view of portion of the generative organs, with transverse sections *a*, *b*, *c*, *d*.

Abbreviations.

alb. g. Albumen gland.
ant. r. m. Anterior retractor muscles.
ant. vg. Anterior vaginal chamber.
b. m. Buccal mass.
h. d. Hermaphrodite duct.
h. g. Hermaphrodite gland.
ms. Muscular tissue connecting the oviduct with body-wall.
œs. Œsophagus.
ovd. Oviduct.
p. Penis.
pr. Prostate.
r. m. Retractor muscle.
s. g. Salivary gland.
s. d. Salivary duct.
st. Stomach.
ut. Uterus.
v.d. Vas deferens.
vg. Vagina.
vg. p. Vaginal papilla.

Art. XXV. — *On the Occurrence of* Paludicella *in New Zealand.*

By A. Hamilton.

[*Read before the Otago Institute, 11th November, 1902.*]

In volume xii. of the "Transactions of the New Zealand Institute"‡ I noted the finding of a species of *Plumatella* in one of the rivers of Hawke's Bay. I have since found the same species (*Plumatella repens*) occurring plentifully in the Water of Leith and other streams near Dunedin. Within the last few months, however, another fresh-water Polyzoon has

* Collinge, *l.c.*, pp. 66–68, pl. i., figs. 1–16; Murdoch, Proc. Malac. Soc. London (part 4), vol. iv., pp. 166–168, pl. xvii., figs. 5, 6.

† Murdoch, Proc. Malac. Soc. London (part iv.), vol. iv., p. 168, pl. xvii., fig. 7.

‡ p. 301.

been noticed by me in the waters drawn from the Ross Creek Reservoir, which supplies the greater number of the houses at the north end of Dunedin. On examination the Polyzoon proves to be *Paludicella ehrenbergi*, Van Beneden, a species beautifully figured and well described in Allman's "Monograph on the Fresh-water Polyzoa."* I now desire by this note to add the genus and species to the fauna of New Zealand. It is one of those widely distributed genera which seem to be found wherever the conditions are favourable, irrespective of geographical locality, and I have no doubt that it will hereafter be found in many parts of the colony when the fauna of our lakes and rivers is better known.

The English species is sometimes found in favourable situations with branches 2 in. long, partly free and partly adherent to stones or stems of aquatic plants. It was originally figured by Van Beneden† and afterwards by other observers, but by far the most beautiful figure is that in the Ray Society's monograph.

Generic description: *Paludicella* is one of the best marked of all the genera of fresh-water *Polyzoa*.

The zoœcia are club-shaped, each of which gives rise to two zoœcia near their upper end, sharply separated from each other by complete septa.

Lophophores perfectly orbicular. These, together with its internal anatomical details, remove it by a well-marked interval from the other genera.

The present locality—Ross Creek Reservoir—is the most southerly of any of those hitherto recorded in the Old or the New World. On the first occasion on which I noticed specimens they had come through the ordinary town water-supply tap, about a mile and a half from the reservoir, and were floating in a white earthenware basin. They at once attracted attention in consequence of their very black colour. This appears to be the normal winter condition, and the black membrane is said to act as a covering for the undeveloped buds, ready to be put forth when warmer weather comes round. This has been worked out in the elaborate monograph by MM. Dumortier and Van Beneden, "On the Natural History of the Fresh-water Polyzoa."‡

Allman says, with regard to this condition, "These hybernaculæ are gemmæ which under the influence of a favourable temperature would have grown into the ordinary lateral branches of the Polyzoon, but which towards winter acquire a

* G. J. Allman, Monog. Fresh-water Polyzoa. London, 1856. Ray Soc.

† Bull. Acad. Brux., tom. vi., 2nd part, p. 278, fig. 1. See also the woodcut in the Cambridge Nat. Hist., p. 502, fig. 250.

‡ Mem. de l'Acad. Roy. des Sciences et Belles Lettres de Brux., 1848.

conical form, and then become for a while arrested in their development. In this state, surrounded by a firm membrane of a blackish-grey colour, they continue until the following spring, when the investing membrane splits to allow of the elongation of the branch."

In November the water was again crowded with fragments of *Paludicella*, and also *Plumatella*, small fresh-water crustaceans, and beautiful water-mites. No doubt the larger water-mains contain masses of these *Polyzoa*, amongst which large numbers of fresh-water animals find a habitation.

Both *Paludicella* and *Plumatella* were found choking the water-pipes of the City of Hamburg, and were considered as having an unfavourable influence on the water-supply, as providing a nidus for undesirable germs. Allman found that this species was "eminently a lover of obscurity," being only found under arches or places where direct sunlight does not penetrate.

Art. XXVI.—*Short Notes on some Insects.*

By F. W. Hilgendorf, M.A., B.Sc.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

Poliaspis media.

I found this Coccid in dense white masses near the base of the leaves of *Phormium tenax*, at Lincoln. Maskell, in his notes on Coccids, records this insect only on *Veronica*, *Leucopogon*, *Cyathodes*, and ferns.

Rhizobius graminis.

Under the roots of cultivated grasses are commonly observed masses of a white mouldy-looking substance. On examining these I found each to contain an immature form of the above Aphidian. Its appearance and size are something like those of the underground form of *Phylloxera vastatrix*. The adult form, of which I found a single specimen, was covered with white waxy threads, as *Schizoneura lanigera* is, and it is doubtless by the shedding of these threads that the common tufts of white substance are formed. The adult, when cleaned of its covering, was dirty-white in colour, with bright-red eyes and a very long and strong proboscis, by means of which it feeds on the roots of grasses.

Anabarhynchus luridus.

I found the larva of this fly about 2 in. under the surface of ground sown in wheat, which at the time was about 3 in.

high. The larva was about 1 in. long, very thin comparatively, and of a light-brown colour. I found it on the 1st October, and the adult fly emerged on the 7th November.

Odontria zealandica.

The night of the 16th November, 1900, was dark, calm, and warm. As daylight failed the grass-paddocks became literally alive with brown beetles. The rustling of their climbing out of the grass was like a strong breeze in an oat-crop, and their droning while on the wing was like the hum of many threshing-mills. In their wheeling flight they struck the head at every moment, and tangled themselves in the hair and beard of observers. This lasted for twenty minutes at the outside—from 7.25 to 7.45—then absolute stillness again. When I looked for the beetles they were discovered in countless numbers in the orchard, eating the younger leaves of pears, apples, and plums. They took no notice of the light of a strong acetylene-lamp, except occasionally to fall off the tree and lie as if dead. I often counted four beetles on a single leaf, and I believe there was a beetle on every leaf. When the tree was shaken they fell to the ground like hail. At 9 p.m. they were still feeding, and there was no change at 10.30 or 12 p.m. or at 2 a.m. At 3.30 a.m. a white streak of light had appeared in the east; many of the beetles were still feeding, but a few were flying homeward. By 4 a.m. they were nearly all gone; but there was only a silent and gradual stealing away, very unlike the great bustle of their approach to their feeding-ground. I have not observed so great a flight since, though there have been several of less magnitude. The 16th was very calm and dull, and at nightfall there was a light breeze from the north-west, which changed at 2 a.m. to a slight air from the south-west, with a feeling of dampness. The minimum temperature for the night was 50° Fahr. By morning on the 17th the wind was again north-east, but by noon there was a howling gale from the south-west, with 1·635 in. of rain, next to the heaviest twenty-four hours' fall during the year. The three succeeding days were also days of south-west wind and slight rainfall.

Another note on the brown beetle may perhaps be of interest. On the night of the 9th November, 1901, I was sleeping on the ground on the slopes of Mount Torlesse. I was suddenly awakened, and soon realised that a beetle had crawled into my ear, and, in the natural efforts of a ground-beetle to get to the bottom of a hole, was clawing against the tympanum, producing intense pain. It continued this scratching while I was striking a wet match, finding a knife, and sharpening a lead pencil, by means of which my com-

panion shortly succeeded in withdrawing piecemeal a specimen of *Odontria*.

Cacœcia excessana.

This common and very variable moth has taken on a new habit of great importance to the general public, and especially to fruit-growers. Meyrick described the insect as probably polyphagous, and Mr. Fereday has recorded, and Mr. Hudson observed, the caterpillar's habit of spinning down a leaf on to a nearly ripe apple or pear and eating away the fruit under the leaf. But the habit that I am about to record is, I believe, new, and certainly very destructive. The moth lays her eggs on the leaves of the apricot, on which the larva feeds till the fruit is nearly ripe. Then it bores its way into the fruit in the groove near the stem. It eats its way under the stem, which thus looses its hold, and the fruit falls to the ground when it is just starting to ripen. An apricot-tree near Lincoln College was loaded with well-formed fruit beginning to take on the colour of ripeness. Within a fortnight the whole of the fruit had fallen off without ripening.

Heliostibes atychioides.

Meyrick notices this moth as frequenting *Leptospermum*. I found its larva in great numbers on the ornamental shrub *Juniperus communis*. The caterpillar is about $\frac{1}{2}$ in. in length and $\frac{1}{18}$ in. broad. It is of a light-brown colour, with the head and thorax dark-brown or black. Some hundreds were feeding on a single branch, and had quite destroyed the tough prickly foliage. When pupating they spin a cocoon binding several of the leaves together, and the general effect was to entirely destroy the branch on which they had been feeding.

Plutella cruciferarum.

The caterpillar of this moth abounds in, and often ruins, the turnip-crops of this district. I found many specimens that had been killed by the entomophagous fungus *Entomophthora radicans*, with which I was able to infect healthy larvæ, though not with that degree of certainty that one could have wished for.

Porina cervinata.

I found very numerous specimens of the larva of this moth under the roots of long-established grass at Lincoln College. The caterpillar is in all respects like that of *P. signata*, as figured by Mr. Hudson in his "New Zealand Moths." I isolated several specimens on the 23rd September, and some of them hatched out on the 15th October.

Bombyx.

We have here imported three bumble bees, *B. virginalis*, *B. hortorum*, and *B. hortorum* var. *harrisellus*. While making some investigations into the harm or good that these bees do to the bean-crop I made the following observations that I think worth recording: Of sixteen specimens of *B. virginalis* that I watched, the whole sixteen bit through the base of the flower to get at the nectar. Of thirteen specimens of *B. hortorum* and of seventeen of *B. hortorum* var. *harrisellus*, the whole number climbed in through the mouth of the flower and got at the nectar by the legitimate means. It thus appears—and, indeed, it would appear from the structure of their probosces—that, as far as the bean goes, *B. virginalis* is useless or harmful, while the other two are useful.

ART. XXVII.—*The* Rotifera *of New Zealand: a Revised and Expanded List.*

By F. W. HILGENDORF, M.A., B.Sc.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

THE object of this paper is to make numerous corrections in the "Contribution to the Study of the Rotifera of New Zealand," which appeared in the "Transactions of the New Zealand Institute," vol. xxxi., p. 107, and at the same time to add to the list the names of some species that I have found since writing my last paper. The corrections referred to have been made largely at the suggestion of Mr. C. F. Rousselet, Curator of the Royal Microscopical Society, and partly as the result of my own further observations.

Order RHIZOTA.

Family FLOSCULARIDÆ.

Genus **Floscularia.**

F. coronetta (Hudson and Gosse, "Rotifera," p. 49): Found by Archdeacon Stock at the Hutt. Recorded, Trans. N.Z. Inst., vol. xxv., p. 193.

F. ornata (H. and G., p. 50): Found among water-lilies, Lincoln College.

F. ambigua (H. and G., p. 53): Found in lily pond at Mount Eden, Auckland.

Family MELICERTIDÆ.

Genus **Melicerta.**

M. ringens (H. and G., p. 70): Found by Mr. A. Hamilton near Napier. Recorded in Trans. N.Z. Inst., vol. xii., p. 301.

Order BDELLOIDA.

Family PHILODINADÆ.

Genus **Philodina.**

P. erythrophthalma (H. and G., p. 99): From Lincoln College pond.
P. roseala (H. and G., p. 99): From roofing-gutters and a cemented pond at Lincoln College. Very numerous at all times of the year.
P. megalotrocha (H. and G., p. 101): From Mount Eden, Auckland.

I found also at Lincoln College a Philodinian resembling probably a variety of this species. I named it provisionally *P. cloacata*. Its chief characteristics are as follows: Size equal to *P. megalotrocha*. Body plump, quickly contracting to the foot, which is slender and 4-jointed. Just anterior to the foot is a large dome-like projection showing like a knot in the outstretched foot. Under this the cloaca lies. The toes are particularly long. Corona ample. Jaws at right angles to length of body, usually greatly obscured. Teeth 2. Cloaca very large. No brain observed. Dorsal antenna multisetate, 3-jointed. Eyes oblong-oblique.

P. microps (H. and G., Supplement, p. 8): Lincoln College; common. Teeth 3, or 3 and 2.

Genus **Rotifer.**

R. vulgaris (H. and G., p. 104): Lincoln College.
R. macrurus (H. and G., p. 107): Taieri Beach. Trans. N.Z. Inst., vol. xxxi., p. 111.

Genus **Callidina.**

C. bibamata (H. and G., p. 111): From Lincoln College.
C. quadridens (mihi): Taieri Beach. Trans. N.Z. Inst., *loc. cit.*
C. venusta: A species with very long antennæ, a variety of which I found at Lincoln College.

The name is given by Mr. D. Bryce, 37, Brooke Road, Stoke-Newington Common, London, but I have no note of where he has recorded the species.

Order PLOIMA.

Sub-order IL-LORICATA.

Family HYDATINADÆ.

Genus **Notops.**

N. minor (Rousselet, "Quekett's Journal," January, 1892) = *Postclausa circularis* and *Postclausa minuta (mihi)*. Trans. N.Z. Inst., *loc. cit.*

The two forms I figured represent different stages in the growth of the same animal.

Genus **Hydatina.**

H. scuta (H. and G., ii., p. 9) = *H. monops (mihi)*. Trans. N.Z. Inst. *loc. cit.*

My former description was made from a single dead specimen, from the front of whose brain the red jaws were protruding and were mistaken for the eye. I have since found other specimens at Lincoln College.

Family NOTOMMATIDÆ.

Genus **Notommata.**

N. pentophthalma (mihi). Trans. N.Z. Inst., *loc. cit.*

N. tripus (H. and G., ii., p. 22): From lily pond, Lincoln College.

Proales decipiens (H. and G., ii., p. 36): Near Lincoln.

Diglena forcipata (H. and G., ii., p. 50): Near Lincoln.

Planoventer varicolor: This is a genus I made for a specimen discovered some years ago. I have never found the animal since, and so leave the name in the meantime. Trans. N.Z. Inst., *loc. cit.*

Genus **Eosophora.**

E. aurita (H. and G., ii., p. 47): Taieri Ferry.

Sub-order LORICATA.

Family RATTULIDÆ.

Genus **Mastigocerca.**

M. lophoessa (H. and G., ii., p. 60) = *M. rectocaudatus (mihi)*. Trans. N.Z. Inst., *loc. cit.*

Genus **Rattulus.**

R. tigris (H. and G., ii., p. 65): From Lincoln College.

My specimens were longer and slenderer in body, foot, and mastax than those shown in Gosse's drawings.

R. cimolius (H. and G., ii., p. 66): From Lincoln College.

R. or *Cœlopus weberi.*

This is a peculiar little Rotifer that I found a single specimen of. It has a carina along the back of its lorica, and projecting from the front of this a horn-like spine. I therefore called my specimen *R. unicornuta;* but it had already been described by Dr. Weber in his "Faune Ratatarienne du Bassin du Leman" as *Cœlopus porcellus*. It was, however, clearly not this species, and it is likely that it will appear as *R.* or *Cœlopus weberi* in the monograph of the *Rattulidæ* that is about to be published by Dr. Jennings, of America.

Genus **Cœlopus.**

C. tenuior (H. and G., ii., p. 68) = *Mastigocerca flectocaudatus (mihi).* Trans. N.Z. Inst., *loc. cit.*

C. brachyurus, Gosse (H. and G., ii., p. 69).

Family Dinocharidæ.

Genus **Dinocharis.**

D. inornata (mihi). Trans. N.Z. Inst., *loc. cit.*

I have seen other specimens of this species, and find them, in outline at least, and in marking of the lorica, exactly like those from which I made my former drawings.

Family Salpinidæ.

Genus **Diaschiza.**

D. tenuior (H. and G., ii., p. 81), found at Taieri Beach and Lincoln College = *D. taurocephalus (mihi).* Trans. N.Z. Inst., *loc. cit.*

The variety *tenua* of my species is not sufficiently different from *tenuior* to justify the new species. I have since found *taurocephalus*, and it is at least a very distinct variety of *tenuior*.

D. semiaperta (H. and G., ii., p. 80): Taieri Beach; Lincoln College.

D. pacta (H. and G., ii., p. 79): Waihola Lake.

D. ventripes (Dixon-Nuttall)?

Family Euchlanidæ.

Genus **Euchlanis.**

E. dilatata (H. and G., ii., p. 90): Lincoln College.

Family Cathypnidæ.

Genus **Cathypna.**

C. hudsoni (Lord): I cannot find where recorded.

Very common; in pool, Mount Eden, Auckland.

Genus **Monostyla.**

M. cornuta (H. and G., ii., p. 98) : Lincoln College.
M. lunaris (H. and G., ii., p. 98) : Waihola Lake.

Family COLURIDÆ.

Genus **Colurus.**

C. amblytelus or *caudatus* (H. and G., ii., p. 104).

I have found several specimens of one of these species at Lincoln College. All my specimens, however, showed two minute eyes, cervical or frontal, while the ventral opening of the lorica showed all gradations from the gradual opening figured by Gosse in *caudatus* to the sudden circular opening figured in *amblytelus*.

Genus **Metopidia.**

M. acuminata (H. and G., ii., p. 107) : Taieri Beach.
M. solidus (H. and G., ii., p. 106).

This is by far the commonest species over the whole of these Islands. My variety *latusinus* was again met with. The *M. ovalis*, of Anderson and Shephard (Roy. Soc. Victoria, vol. xiv., n.s., part i., p. 69, 1892), is evidently a variety between my two varieties, and to bring the matter into line either *M. ovalis* should be regarded as a variety or my *latusinus* as a species. With the exception of *M. ovalis*, I have found no connecting-links between *solidus* proper and *latusinus*.

M. triptera (H. and G., ii., p. 108).

This charming little animal is common in the neighbourhood of Lincoln.

Family PTERODINIDÆ.

Genus **Pterodina.**

P. patina (H. and G., ii., p. 112).

This species I found in water squeezed out of swamp moss near Lincoln, and in a small creek running into Lake Waihola it was found in very large numbers.

Family ANURÆIDÆ.

Genus **Anuræa.**

A. hypelasma (H. and G., ii., p. 103) : Auckland.

Genus **Notholca.**

N. jugosa (H. and G., Supplement, p. 56; Gosse, Journal R.M.S., 1887, p. 1) = *N. regularis (mihi).* Trans. N.Z. Inst., *loc. cit.*

I have found at Lincoln many specimens of this species showing gradations between the two varieties *regularis* and *jugosa*.

Art. XXVIII.—*On a New Species of* Odontria.

By J. H. Lewis, F.E.S.

Communicated by W. W. Smith, F.E.S.

[*Read before the Philosophical Institute of Canterbury, 3rd September, 1902.*]

Plate XXXI.

Odontria epomeas, n. s.

Opaca, pubescens, picea, thoracis marginibus humerisque elytrorum testaceosignatis, capite grosse subseriatim punctato. Long. 13 mm.; lat. 6·7 mm. ♀.

Suboblong, opaque, velvety, clothed above with short yellow hairs; head, thorax, and epipleuræ with long erect setæ; thorax pitchy-brown, with the sides and a central streak testaceous; elytra pitchy-brown, with numerous small irregular yellow marks, the shoulders each with a short testaceous vitta. Trophi and limbs reddish-yellow. Head in front shining pitchy-brown, behind yellow.

Clypeus coarsely and closely punctured, obtusely rounded, and with the margin regularly elevated. Head with coarse punctures arranged in irregular rows, with smooth interspaces. Thorax with front angles acute. Scutellum testaceous, punctate. Elytra with sculpture as in *O. occipitalis*. Abdomen with fine punctures and longitudinal scratch-like sculpture.

Antennæ with 5th joint simple, club short, 3-articulate.

Rakaia Gorges. Coll., Miss Jones.

This species is closely allied to *Odontria occipitalis*, Broun, from which it may be distinguished by the yellow central vitta of the thorax and the humeral streaks. The coloration of the head is different, and probably also the sculpture, the punctation in *O. epomeas* extending back as far as in any species with which I am acquainted.

EXPLANATION OF PLATE XXXI.

Odontria epomeas, n.s.

Fig. 1. Head; × 6.
Fig. 2. Fore tibia; × 10.
Fig. 3. Antenna; × 30.

ART. XXIX.—*On a New Species of Earthworm from Norfolk Island.*

By W. BLAXLAND BENHAM, Professor of Biology, University of Otago.

[*Read before the Otago Institute, 14th October, 1902.*]

Plates XXII.–XXVI.

OWING to the kindness of Professor Dendy I have been enabled to examine a small collection of earthworms made by Mr. Laing on Norfolk Island. The specimens were in two lots. One lot turns out to consist of introduced European worms—*Allolobophora caliginosa*—a species which seems especially hardy and capable of adapting itself to a great variety of conditions, as it is now extremely widely spread, being met with wherever commercial intercourse with Europe has been established. The second lot consists of a few fragments (but, fortunately, two of these were the anterior moieties) of a worm which belongs to the genus *Megascolex*, the headquarters of which is Australia, though several species occur in Ceylon, and a few elsewhere in the Oriental region. The species does not agree with any hitherto described worms, and I suggest the specific name "*laingii*" for it. Owing to the poorness of preservation several points were not fully followed up, so that certain gaps in our knowledge of its anatomy remain.

Megascolex laingii, n. sp.

Colour, in alcohol, purplish-red, with a darker line round the middle of each segment; pale below.

Length of longest fragment 20 mm., by 2 mm. in diameter, containing 28 segments.

Prostomium broad, its base extending nearly across the peristomium; its length short; imbedded about one-third into peristomium. No posterior groove—*i.e.*, "epilobic."

Chætæ, in mid-body, about 32—*i.e.*, 16 on each side—with a distinct dorsal and ventral gap, the latter rather the greater. The number gets smaller anteriorly, as does the ventral gap, thus: Total number on 6th segment, 24; 3rd segment, 20; 2nd segment, 16. The more dorsal chætæ of each ring are further apart than the more ventral ones.

The *clitellum* is most unfortunately not yet developed.

The *male pores* are on small rounded papillæ on the 18th segment, in line with chæta *b* (*i.e.*, the second from below); each papilla is continuous on its external margin, with a short longitudinal ridge extending across the 18th segment. On the 17th segment is a pair of transverse ridges, or oval papillæ,

meeting in the median ventral line so as to form a dumb-bell-shaped accessory copulatory structure.

The *spermathecal pores* are between segments 7/8 and 8/9, close to the ventral line, in line with chætal gap *b/c*. On segments 10, 11, and 12, in line with these pores, is a series of pale areas, each with a slight pitting in its centre, indicating copulatory tubercles.

I did not find the *oviducal pores.*

Dorsal pores commence behind segment 5.

Internal Anatomy.

The dorsal vessel is single. The last heart is in segment 12. I did not note the total number of hearts.

The gizzard is small, thin-walled, cylindrical, and occupies segment 5.

The œsophagus is slightly dilated in segments 13 and 14, though no definite gland is formed.

The intestine commences in the 16th segment.

The worm is micronephric, and anteriorly is a large glandular body, which is probably a pepto-nephridium.

The Reproductive System.—The testes, ovaries, funnels, and ducts are in the usual positions.

Two pairs of botryoidal sperm-sacs lie in segments 9 and 12, while the intervening segments were occupied by loose sperms.

The prostates, or spermiducal glands, are small, limited to the 18th segment. Each is flattened, lobulated, with a short muscular duct, near the origin of which there is a distinct separate lobule of glandular substance, so that the gland is unequally bilobed.

I observed no penial chætæ.

The spermathecæ are two pairs, in the 8th and 9th segments respectively. Each consists of a globular copulatory sac, with a single elongated diverticulum opening by its own duct into the short duct of the copulatory sac.

Remarks.

In some respects this worm agrees with *M. minor*, Spencer,* from Queensland—*e.g.*, in its small size, number of chætæ, position of dorsal pore, absence of œsophageal glands, and number of spermathecæ and of anterior copulatory glands. On the other hand, Spencer describes vascular swellings of the œsophagus in segments 8, 9, and 10, and a bilobed, equilobed, spermiducal gland. He makes no reference to copulatory glands on the 17th segment, which are so conspicuous in the present species.

For explanation of figures, see pp. 289, 290.

* Baldwin Spencer, "Further Descriptions of Australian Earthworms" (Proc. Roy. Soc. Victoria, 1900, xiii. (n.s.), p. 49).

ART. XXX.—*On an Earthworm from the Auckland Islands* —Notiodrilus aucklandicus.

By W. BLAXLAND BENHAM, Professor of Biology, University of Otago.

[*Read before the Otago Institute, 14th October, 1902.*]

Plates XXII.-XXVI.

THE material which forms the subject of the present note was collected by Captain Hutton during his recent trip to the southern islands. He was good enough to send it to me early in 1901. The collection consisted of six specimens, all belonging to the same species, which is new to science.

Notiodrilus aucklandicus, n. sp.

Colour.—The worms are, in the preserved condition, greyish in colour, with grey-brown clitellum, and the preclitellar region sienna-brown. The grey tone is due to the transparency of the body-wall allowing the contents of the gut to be seen; nevertheless, pigment dots are present in the body-wall.

Dimensions.—The largest specimen measures 93 mm., the smallest 78 mm.; two others are 82 mm. in length The diameter of the first is 2·5 mm. in middle of body, but of the smallest 3·5 mm. The worms are, unfortunately, very soft, and imperfectly preserved, so that in handling the dimensions vary. One of the medium-sized specimens consists of 107 segments.

The *prostomium* is imbedded about one-third into the peristomium, and is epilobic.

The eight *chætæ* are separate: $aa = dd$, $ab = \frac{1}{2} aa$, $bc = cd > ab$.

The *clitellum* is not quite fully developed in any specimen, but in the most mature it extends from half 13 to half 17 (in two specimens covers only 13 to 16). The anterior region is complete ventrally, but the under-surface of the 16th segment is devoid of glandular tissue.

Genital Pores, &c.—The porophores on 17 and 19 are in line with chæta *b*, which, with *a*, is absent on these segments. Both these chætæ are present on the 18th segment. A spermatic groove, convex outwards, passes over this segment in the usual way. Accessory copulatory tubercles exist, though there is some variability in their distribution; but from an examination of the five individuals which exhibit them their location is as follows:—

A. In line with chæta *a*: A pair of small tubercles on 17 and 19, near the anterior margin, and mediad of the porophores; a pair of similar tubercles on the 18th, near the hinder margin.

B. In line with chæta *b*: A pair of larger tubercles on segment 20, around chæta *b* (and, in one case, also on the 21st segment); a pair of similar tubercles on the 16th segment; and a pair on the 10th segment.

The *spermathecal pores* in the usual position, in line with chæta *b*. The *nephridiopores* in line with chæta *c*.

Dorsal pores are present, at any rate, behind the clitellum.

Internal Anatomy.

The dorsal vessel is single; the last heart is in the 12th segment.

Alimentary System.—There is no gizzard perceptible on dissection. The œsophagus bears two pairs of distinct glands, in segments 13 and 14 respectively. The intestine commences in the 16th segment, and is without a typhlosole.

Reproductive System. — The testes, sperm-ducts, ovaries, and oviducts occupy the usual positions. There are two pairs of botryoidal sperm-sacs, in the 11th and 12th segments. The spermiducal glands are long, folded, and tubular, but apparently of rather looser texture than is usual in Acanthodrilids. Each is provided with a narrow and long muscular duct, which is distinctly swollen where it penetrates the body-wall. Each gland passes through four to six segments, and even the duct passes backwards into the segment following the pore.

Penial chætæ are present. Each sac contains a couple, a longer and shorter, of functional chætæ, together with their replacers. Both have the same general form. The tip is somewhat spoon-shaped, while the shaft is ornamented by numerous fine transverse and serrated ridges.

The spermathecæ are in the usual segments. Each is a globular sac, with distinct narrow duct about half as long as the sac itself. This duct receives, as it passes through the body-wall, two sausage-shaped diverticula, which thus seem to be independent of the sac.

Remarks.

This worm differs from *N. macquariensis*, F.E.B., in several respects, as a comparison with the account* published

* "On some Earthworms from the Islands around New Zealand" (Trans. N.Z. Inst., xxxiii., p. 132). In that article I stated that the penial chætæ are "hooked" at the tip. This I now find, from observation of several specimens, to have been an accidental bending of the soft tip. The hook exists in the preparation I then made, but I have not observed it in other cases.

by me in 1900 will show. There is, however, a special interest attaching to both these species, since they agree more closely with the species of *Notiodrilus* found at the Cape of Good Hope and at South Georgia, Falkland Islands, and Tierra del Fuego, than they do with the species of the genus occurring in New Zealand itself.

For explanation of the figures, see pp. 289, 290.

ART. XXXI.—*On the Old and some New Species of Earthworms belonging to the Genus* Plagiochæta.

By W. BLAXLAND BENHAM, Professor of Biology, University of Otago.

[*Read before the Otago Institute, 14th October, 1902.*]

Plates XXII.-XXVI.

DURING the four years in which I have resided in New Zealand I have been accumulating a considerable number of earthworms collected in various parts of New Zealand. Amongst other friends and gentlemen who have been good enough to make collections for me, or to send me those worms already in their collections, I have to thank Captain Hutton, who placed his collection at my disposal; Professor Dendy; Mr. H. B. Kirk; Mr. W. W. Smith, who on several occasions has, at my request, sent me particular species, and constantly sends me material as he meets with it; Mr. H. Suter, and others whose names appear in the following communications. I have as yet had time only to examine critically a small proportion of this material, and I have devoted this article to the description of four new species of *Plagiochæta*, together with remarks on Captain Hutton's species. As in a previous article, I here deal only with characters rendered evident by dissection. I reserve certain interesting and important details of microscopic structure for another paper.

It will be seen that the new species of the genus differ in various characters from the original species, and it will probably be necessary to subdivide the genus. But for the present I use the term "*Plagiochæta*" in a wide sense, to include endemic earthworms, which differ from typical Acanthodrilids (*Notiodrilus, Maoridrilus*) and from *Octochætus* in possessing numerous chætæ on each segment in place of the more usual eight. But it seems desirable to await further research in greater detail before the genus is subdivided. This matter, however, I hope to deal with in a forthcoming article elsewhere.

Plagiochæta sylvestris, Hutton, 1876 (= *P. punctata*, Benham, 1892).

In the year 1876 Captain Hutton* gave a brief account of the external anatomy of several New Zealand earthworms, amongst which were two species which he placed in the genus *Megascolex*—viz., *M. sylvestris* and *M. lineatus*. In the year 1892 I gave a detailed account† of the anatomy of a worm collected on Maungatua, for which it was necessary to create a new genus, and I termed it *Plagiochæta punctata*. At that time I was ignorant of Captain Hutton's article; but in 1892 Mr. Beddard‡ suggested that in all probability *M. sylvestris* belonged to this new genus. This supposition was confirmed by me when, in 1898, I had the opportunity of examining Hutton's types,§ preserved in the Otago University Museum, and in a note upon these types I pointed out that "it is difficult at present to determine whether *M. sylvestris* is or is not identical with *P. punctata*"; and I recognised that *M. lineatus* belonged to the same genus. A renewed examination of the type, and of other specimens collected in the neighbourhood of Dunedin, where the type was collected, has enabled me to establish this identity, and, further, to indicate the differences, external and internal, that exist between *P. sylvestris* and *P. lineatus* in a more detailed manner than was possible in my former note.

Habits.—*P. sylvestris* occurs in rotten logs in the remains of the bush country that forms the Town Belt around Dunedin, as well as on the slopes of Maungatua, and no doubt elsewhere. It is still pretty plentiful in our Town Belt, and I have found it especially in fallen *Griselinia* trees. The colour is chocolate, and closely resembles the vegetable mould—the digested wood—amongst which it lives. It is marked, as I noted in 1892, with white spots, in which the chætæ are inserted, while the nephridiopores are also indicated by still more conspicuous white spots, readily visible to the naked eye. The species is extremely active, and moves in a straight line with great rapidity, using its mouth as an organ of adhesion. It contracts its body to about half its length, then thrusts its head forward and extends itself fully; there is no wriggling or undulation of the body. When extended one specimen measured was 2 in. (50 mm.);

* Hutton: "On New Zealand Earthworms in the Otago Museum" (Trans. N.Z. Inst., ix., p. 352).

† Benham: "Notes on Two Acanthodriloid Earthworms from New Zealand" (Quart. Journ Micros. Sci., xxxiii., p. 294).

‡ Beddard: "On some New Species of Earthworms from various Parts of the World" (Proc. Zool. Soc., 1892, p. 667).

§ Benham: "A Re-examination of Hutton's Types" (Trans. N.Z. Inst., xxxi., p. 156; and Ann. Mag. Nat. Hist. (7), iii., p. 137).

when contracted, $1\frac{3}{16}$ in. (25·5 mm.). It appears to move backwards with almost the same ease with which it moves forwards.

But what is most remarkable is its ability to climb up a vertical surface. I placed a specimen in a clean dry glass beaker 4 in. in height. It climbed up this in a straight line, and dropped over the edge on to the table. Here it remained without a wriggle for a few seconds, in the same position as it fell. I noted that it moved even more rapidly vertically up this smooth glass than along the horizontal surface of the table. On holding the beaker in various positions, it nearly always took a vertical direction.

The worm, when slightly pinched with forceps, readily breaks into two pieces. It is not difficult to imagine the value of these habits in the struggle for existence. The negative geotaxis is, of course, of importance in gaining its normal habitat. Its ready autotomy probably protects it if perchance it is touched by a bird probing the log for grubs, &c.

Anatomy.—The two species, *P. sylvestris* and *P. lineatus*, agree closely with one another in external form and in certain structural characters, and differ in some of these respects from certain other species to be described below. Each is about $1\frac{1}{2}$ in. to 2 in. in length, and contains from seventy to ninety segments. The body is relatively broad in proportion to the length, and is broadest in the middle.

The *chætæ* are about fifty in number, set in couples,* of which there are twelve or thirteen on each side. A distinct dorsal and ventral gap exists, the width of which in relation to the ordinary gap between couples is variable, being at least twice, or even thrice, the latter.

In my note of 1898 I laid some stress on the differences in the widths of these median gaps, but further comparison leads me to consider such differences as individual or even segmental variations.

The *clitellum* always covers segments 14 to 17, though the number of fully mature individuals available does not enable me to be certain as to any constant differences between the two species in this respect.

The *porophores* on 17th and 19th segments are set in a slight depression, capable of being converted into a narrow furrow on contraction, so that the porophores meet their fellows. This depression involves the ventral surface of segments 16 to 20. The porophores are in line with the lowest couple of chætæ; the male pore, on the 18th, is just outside this couple. There is no spermatic groove, such as

* As I have already stated (1898), Captain Hutton committed a *lapsus calami* in attributing to *P. lineatus* a "continuous circle" of chætæ.

exists in *Maoridrilus* and other Acanthodrilids, but the depression is limited laterally by a slight ridge just lateral of the porophores.

The *spermathecal pores*, between segments 7/8 and 8/9, are in line with the ventralmost couple of chætæ.

The *nephridiopores*, large and conspicuous, alternate in the greater part of the body (as I showed in 1892), being usually in front of the 4th and the 10th couple of chætæ, counting from below.

As will be seen below, the internal anatomy presents definite distinctive features in these two species.

P. sylvestris, Hutton.

The *prostomium* is "epilobic"—*i.e.*, it is prolonged backwards, or imbedded in the 1st segment for about two-thirds of its length (see Hutton's fig. E).

The *clitellum* in some of the specimens does not extend beyond segments 14 to 17, but in the type itself, as well as in the specimen named "*punctata*," it intrudes upon the 18th segment; and in another local specimen I note that it commences in the 13th. Possibly, therefore, when fully developed it covers the six segments—13 to 18.

Copulatory tubercles are present—at any rate, in some of my specimens—in the form of transverse oval glandular areas extending across the ventral surface of segments 11 and 12.

Of internal organs the following appear to be of diagnostic value:—

The *dorsal vessel* is double up to the 15th segment; the two vessels lie close together, and in my account of *P. punctata* I figured the vessel as single. It is, however, distinctly double in the intestinal regions. In the 14th segment the two canals still exist, but are bound together in one coat; in the 13th the fusion is complete, and a single vessel runs forwards.

There are three pairs of hearts, the last being in the 12th segment.

There is no gizzard recognisable on dissection. The œsophagus bears a pair of large glands in the 14th segment, and frequently these protrude into the 13th; indeed, in one case this portion was constricted off so as to form a small and apparently independent gland. The intestine commences in the 16th segment.

With regard to the *reproductive system*, there are four pairs of sperm-sacs even in the type, notwithstanding my statement (1898, p. 162) to the effect that there are only three pairs. My laboratory note, as well as a re-examination of the type, gives four as the true condition, as I described in 1892 for *punctata*.

The *penial chætæ* are especially diagnostic. Each is a long gently curved bristle practically smooth on its shaft, and terminated in a blunt point, which is not upturned.

The *spermatheca* is globular, with a short wide duct, into which opens a single tubular diverticulum, which invariably, as far as my observations on several individuals go, is præseptal.

P. lineatus, Hutton.

Hutton's original specimen was obtained at Queenstown, on Lake Wakatipu, in Otago. I have been able to examine other specimens, collected by Mr. Malcolm Thomson on Ben Lomond, a mountain 5,747 ft. in height overlooking the town. The differential characters are as follows:—

The *prostomium* is tanylobic—*i.e.*, its prolongation completely cuts through the 1st segment, as Captain Hutton shows it in his fig. F (1876).

The *clitellum* appears to be limited to segments 14 to 17, and I have observed no copulatory tubercles; but in both of these characters I must for the present reserve judgment, owing to lack of sufficient material.

The *dorsal vessel* is single; and the hearts are in 10, 11, and 12.

There is a small *gizzard* in segment 6, recognisable on dissection.

The œsophageal gland is in segment 14, projecting slightly into the 13th segment.

There are only three pairs of sperm-sacs, in segments 9, 11, and 12.

The *penial chætæ* are longer and more delicate than in *P. sylvestris*, and the tip is bent upwards and slightly excavated, so as to be spoon-shaped, though in side view the tip is pointed. But, further, the shaft is marked by numerous distinct but fine, interruptedly transverse, low ridges, finely serrated.

The *spermatheca* is ovoid, with a short and comparatively narrow duct, into which there open two short and somewhat globular diverticula, the lower of which is præseptal. One of these diverticula—perhaps both—is lobed—*i.e.*, its free extremity is notched by one or two furrows. In the type it is the lower which is thus notched; in the Ben Lomond specimen it is the upper one.

These two characters—the penial chætæ and the spermathecæ—are very definite differential features of these closely similar species.

Plagiochæta lateralis, n. sp.

Locality.—The shore of Lake Thompson, 1,100 ft. above sea-level, on the track from Lake Te Anau to George Sound. Collected by Mr. J. Mackenzie.

Colour.—Pale-greyish, with dark-brown clitellum.

Dimensions.—The longest of the dozen specimens measures 55 mm., with a diameter of 5 mm. The body is rather depressed, with a slight groove along the median dorsal and ventral surfaces. The number of segments is 100.

The *prostomium* is half epilobic, with a transverse furrow before the end of the longitudinal furrows.

The *chætæ* are twenty-four (about) in each segment. They are not in couples, but are arranged in two groups on each side, an upper and a lower, separated by a distinct lateral gap, which peculiarity suggested the specific name. The lower group consists of five chætæ, the upper group of seven chætæ; the latter are further apart than the former. The dorsal gap is greater than the ventral, and each is greater than the lateral. The arrangement may be represented by the following formula, in which the vertical lines represent chætæ and the numerals indicate the relative distances, as measured by an eye-piece micrometer on the flattened skin. V, L, and D are the ventral, lateral, and dorsal gaps respectively.

$$9 \mid 2\tfrac{1}{2} \mid 2 \mid 2\tfrac{1}{2} \mid 2\tfrac{1}{2} \mid 5\tfrac{1}{2} \mid 3 \mid 3 \mid 4 \mid 4 \mid 3 \mid 4 \mid 12.$$
$$V \quad a \quad b \quad c \quad d \quad e \quad L \quad f \quad g \quad h \quad i \quad j \quad k \quad l \quad D$$

No doubt the actual distances vary, not only in different specimens, but in different parts of the body.

The *clitellum* covers segments 14 to 17 inclusive; it does not extend over the ventral surface, but ceases at about the level of the porophores.

Genital Pores, &c.—The porophores are feebly developed on 17 and 19, and are in line with about chæta *e*—*i.e.*, almost laterally placed. There are four chætæ below each, and four chætæ below the male pore in 18th segment; and sections show a 5th chæta close to the pore in each of these segments. These chætæ are further apart on these segments than elsewhere. There is a distinct and curved spermatic groove, convex outwards. In some of the specimens copulatory tubercles exist, but asymmetrically on the right or left of segments 18 or 20. In none are they fully developed, when, no doubt, they will be paired.

The oviducal pores are in line with the gap *b/c*, the spermathecal pores between 7/8, 8/9, in line with the chætal gap *e/f*; and in several of the individuals there is a pair of pitted tubercles on the 8th segment, just behind the chætal ring, in line with the gap *d/e*.

Dorsal pores are present, at any rate, behind the clitellum; I see no nephridiopores on the skin, but in section I find them in the lateral gap.

Internal Anatomy.

There are four stout *septa* behind segments 9, 10, 11, and 12; those behind segments 6, 7, and 8 are thin and much pouched backwards.

Vascular System.—The dorsal vessel is double, but united at the septa, as far forwards as the 12th segment. In the 11th the two vessels are bound together in a common envelope, though the canals are separate; but in the 10th they have united, and the single vessel thus formed continues forwards. The last heart is in the 13th segment. Both this and the heart in the 12th are unconnected with the dorsal vessel; they are therefore "enteric hearts," being connected probably (for I have not examined this point) with a supra-enteric vessel. But the two hearts in 10 and 11 are "lateral hearts," being connected with the dorsal vessel.

Alimentary System.—The gizzard is large, and occupies segment 6, and pushes back the next three septa. The œsophagus remains very narrow, but thick-walled, as it passes backwards to the 19th segment; there is no enlargement to form a gland. The gut becomes thin-walled in the 20th segment, and dilates to its full size in the next, whence it becomes apparently spiral.

Excretory System.—The worm is meganephric.

Reproductive System.—The testes, funnels, ovaries, and oviducts occupy the usual position. There are only two pairs of sperm-sacs, in segments 9 and 12 respectively, the intervening segments being occupied by a mass of loose sperm. The spermiducal glands are thick, convoluted, and confined to their proper segments. The muscular duct is short and narrow.

There are no penial chætæ. In segment 18 there are a series of stout muscles, which start from each side of the nerve-cord and pass outwards and upwards to be inserted in the body-wall on the dorsal surface of each side. These "tranverse muscles," as they may be termed, are probably employed during the process of copulation. The effect of contraction, as seen in preserved specimens, is to cause a deep depression of the ventral surface of segments 17 to 19, and at the same time the porophores become more prominent. Such "transverse muscles" are known in other earthworms—*e.g.*, *Octochætus*—and their presence seems to be associated with the absence, or, at any rate, small size, of penial chætæ.

There are two pairs of spermathecæ, in the usual segments. The chief part, or "copulatory sac," is relatively large,

transversely ovate, and the duct is scarcely distinguishable on dissection, but receives right and left a small ovate diverticulum with a long narrow duct.

Plagiochæta rossii, n. sp.

Locality.—Five specimens were collected in the bush on the shore of Lake Te Anau in 1900. I name this species after the collector, Mr. Donald Ross.

The *colour*, in formol, is purplish-brown, with a darker-brown median dorsal stripe. The preclitellar region is greyish-brown.

Dimensions.—The mature individuals vary from 105 mm. to 165 mm. in the preserved condition. In a specimen measuring 158 mm. its greatest diameter is 7 mm. at segment 8, and also behind the clitellum. The preclitellar region is 20 mm. and the clitellum 11 mm. in length. This worm consists of 112 segments.

The *prostomium* is epilobic (three-quarters), without a posterior groove.

The *chætæ* are about thirty-two to thirty-six in each segment, not in couples. Each chæta is implanted in a light spot. There is no perceptible diminution anteriorly, for I count thirty-two on the 7th segment and thirty-four on the 3rd segment. There are small ventral and dorsal gaps, but no lateral gap, the series of sixteen or eighteen chætæ on each side being practically equidistant.

The *clitellum* extends from 13th to 17th segment, and in the largest individual the 18th segment differs in colour from the 19th, and looks as if it, too, would become part of the clitellum. The organ is continuous ventrally in its anterior region, but on segments 16 to 20 is a white transversely oval genital area, containing the genital pores.

Genital Pores.—The porophores are prominent. There is no true spermatic groove, but a ridge passes from 17th to 19th segment on each side, having a rather peculiar arrangement. Starting from the 17th porophore, the ridge curves down the posterior face with an outward sweep and reaches the intersegmental furrow, where it disappears. A similar ridge occurs on the anterior face of the porophore on the 19th segment. Then in the 18th is a curved ridge, convex outwards, connecting the two other ridges. The ridge is a rounded prominent structure, forming the outer boundary of an indistinct furrow whose inner boundary is formed by the glandular tissue of the body. This ridge seems to contrast with the definite groove found in many Acanthodrilids, for in them the groove is the conspicuous structure; here, in *Plagiochæta*, it is the external (and only) ridge that catches the eye. How far we may distinguish these two things is uncertain, but the

structure just described may, for convenience, be termed a "spermatic ridge," and we meet with it in other species of this genus.

The oviducal pores are close together in front of the ventral gap, enclosed in a definite pale oval patch.

The spermathecal pores are in line with chætæ *c* and *d*. On the ventral surface of each of the segments 9 and 10 is a pair of copulatory tubercles, and indications of another pair on the 11th segment.

Dorsal pores are distinct from the clitellum backwards.

Internal Anatomy.

The six *septa*, behind segments 10 to 15, are especially stout, and the two in front of these less so.

The *dorsal vessel* is double right up to the pharynx, being connected only at the septa. The hearts are in segments 10, 11, 12, and 13.

Alimentary System.—The gizzard lies partly in the 6th but chiefly in the 7th segment, the septum, 6/7, being inserted on its walls. The œsophagus is dilated in segment 15 to form, apparently, a gland, though it is not well defined externally. The lining of the œsophagus as it passes through segments 12 to 15 is raised up into numerous closely set, laterally flattened vascular villi, but no distinct lamellæ such as are usually associated with an œsophageal gland occur. In the 16th segment the gut becomes paler and diminishes in size, and does not become dilated to form the intestine till segment 20 is reached, after which it is deeply constricted as it passes through the septa.

The worm is *micronephric*, the excretory organ being represented in each segment by a vertical series of small tufts of tubules passing upwards along the body-wall.

Reproductive System.—The testes, ovaries, and their ducts have the usual position. There are four pairs of sperm-sacs, lying in segments 9, 10, 11, and 12. The spermiducal glands are confined to their proper segments. The glandular part, tubular as usual, is convoluted and coiled into a ball. The muscular duct is long, very narrow, and undulating.

No penial chætæ appear on dissection. Transverse muscles are well developed in segment 18 and partly in the neighbouring segments.

The *ovaries* are noticeably large, passing along the septum from near the ventral vessel upwards for nearly one-third the semi-circumference of the septum. The funnels of the oviducts are also unusually prominent.

The *spermathecæ* are large ovoid sacs, with short ducts. The duct of each sac is beset with groups of small somewhat botryoidal diverticula, so that when viewed from above they appear as a fringe round its neck.

Plagiochæta ricardi, n. sp.

Locality.—Four specimens of this fine worm were obtained by Mr. Richard Henry on Resolution Island, at the south-west corner of the South Island. In a note he writes, "A common worm, living 6 in. down in peaty soil, mostly on the shady side of a hill. It is a favourite food of the roa (*Apteryx haastii*), which, when hunting for food, walks slowly, with gentle tread, and its head held as if listening. When the bird gets hold of a worm it breaks the latter up to get rid of the gut."

Colour (in formalin) dark purplish-brown—in fact, almost purple dorsally. When transferred to alcohol the purple tint becomes sienna-brown.

Dimensions.—This species is of considerable size and bulk in life. The four specimens are from 180 mm. to 290 mm. in length, with a diameter ranging from 10 mm. to 14 mm. in the middle of the body; but this is not the greatest diameter. Of these only two—measuring 260 mm. and 290 mm.—are mature. The former of these two contains 173 segments.

The *prostomium* is epilobic (half), without a posterior groove.

The *chætæ* are not in couples, nor in paler spots. There are from fifty-two to sixty-four chætæ in the post-clitellar region, separated into a right and left series by a dorsal and a ventral gap of about thrice the width of an inter-chætal gap. There is no sensible diminution in number of chætæ anteriorly. In the clitellar region the more ventral chætæ, *a–d*, are further apart than elsewhere.

The *clitellum* occupies segments 14 to 20, and even the 21st is slightly glandular. The organ is incomplete ventrally, ceasing at the level of the porophores.

Genital Pores.—The porophores and "spermatic ridge" are similar to those of *P. rossii*, but the latter is here less curved. The pores are in line with chæta *c*, which is absent, though *a* and *b* are present on segments 17, 18, and 19. The oviducal pores are in line with the gap *a/b*. The spermathecal pores are indistinguishable externally. It appears that formol, though excellent as a temporary preservative of colour, causes earthworms to shrink a good deal, and the pores become closed.

Internal Anatomy.

The seven *septa* behind segments 8 to 14 are thick, but especially those of 9 to 13. The septum 14/15, as well as the two following septa, are pouched forwards, so that the cavity of the 17th segment is increased beyond its usual size.

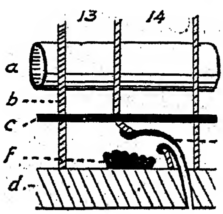
The *dorsal vessel* is distinctly double, right up to the pharyngeal region. The last heart is in segment 13.

The Alimentary System.—The gizzard is elongated, but wholly confined to segment 6. There is a large œsophageal gland in segment 12, behind which the gut is noticeably reduced in size—not only in breadth but also in length—owing to the reduction of the segmental cavities already referred to. It does not commence to dilate till the 18th segment to form the intestine.

The worm is *micronephric*, the tufts of tubules being concentrated near the nerve-cord. I have been unable to trace the nephridium to the surface, but there are well-developed funnels.

Reproductive System.—The position of the gonads is altogether unique. Both testes and ovaries are situated not on the septa bounding the segments, but *on the floor of the body.* Each testis is elongated in a direction parallel with the long axis of the body, and extends backwards to the posterior wall, terminating below the corresponding funnel. In the case of the ovary the same arrangement obtains; but the cavity of the 13th segment is greatly reduced, except below the ventral vessel, where the septum 13/14 is pouched backwards to form a tunnel-like pocket, which reaches nearly as far as septum 14/15. It is on the floor of this pocket that the two ovaries are placed; and, as the funnel of the oviduct is carried forwards by the overarching septum, the ovary comes to lie underneath the lip of the funnel.

Diagrammatic longitudinal section through segments 13 and 14.



a, gut; *b*, septum; *c*, ventral blood-vessel; *d*, body-wall; *e*, oviduct; *f*, ovary.

There are four pairs of sperm-sacs in the usual segments. The spermiducal glands are somewhat flattened and undulating.

There are no penial chætæ, but "transverse muscles" occupy segment 18.

Each of the spermathecæ (in segments 8 and 9) is a subconical sac, with short duct, and around the latter is a nearly

complete circle of short, sessile, globular diverticula, hiding the duct when viewed *in situ*.

Plagiochæta montana, n. sp.

Locality.—In bush soil near Lake Thompson, 1,100 ft. above sea-level, on the track from Lake Te Anau to George Sound. They were collected by Mr. Mackenzie during the formation of this track.

Dimensions.—The collection contains a considerable number of individuals, ranging from 36 mm. by 5 mm. up to 190 mm. by 12 mm. Of these only a few are mature, and the smallest possessing a clitellum is 140 mm. by 8 mm. A specimen measuring 182 mm. contains 145 segments. The body is rather broader than high.

Colour.—Brick-red, browner anteriorly, with a brown clitellum. The chætæ are inserted in white rings girdling the segments.

The *prostomium* is epilobic, with a posterior groove halfway along the 1st segment.

The *chætæ* are about thirty-six to forty per segment, not in couples, but form a right and left series on each side, separated by a dorsal and ventral gap of about three times the interchætal gaps, which, as in other species, are by no means constant in their width. The number of chætæ diminishes somewhat, but not materially, anteriorly. I counted thirty-two on segment 4 and only twenty-four on segment 11. As usual, the ventral chætæ on the hinder clitellar segments are rather more widely spaced than elsewhere.

The *clitellum* covers segments 14 to 20, the limits of the organ being very distinct. It is incomplete ventrally, ceasing at about the level of the porophores.

The large porophores are connected by a "spermatic ridge." The body here bulges out laterally and is depressed mesially, as in other species, possessing "transverse muscles" in the 18th segment. The male pore is on a slight papilla. The three pores are in line with the gap *c/d*. Chætæ *a* and *d* are present on these three segments, but *b* and *c* are absent. The oviducal pores lie in front of the gap *a/b*; the spermathecal pores in front of the chæta *d*, in the intersegmental furrows 7/8 and 8/9.

Dorsal pores are evident behind the clitellum.

Internal Anatomy.

There are eight stout *septa* behind segments 9 to 16 those of 10th, 11th, and 12th segments are especially stout. All are much thicker than in *P. rossii*.

The *dorsal vessel* is double up to the 4th segment; the two are connected by short transverse vessels præseptally. The

last heart is in segment 13; it and the heart in 12 are "enteric," while in 10 and 11 are "lateral hearts."

The Alimentary System.—The gizzard is large, occupies segments 6 and 7, the septum 6/7 being attached round its middle. The œsophagus bears a dilatation in segment 15, which is not constricted from the main tube. The gut then narrows, but in the 18th commences to increase in diameter till it has reached its full diameter in the 23rd segment.

The worm is micronephric.

Reproductive System.—The testes and ovaries are situated on the hinder wall of their segments, in each case underneath the funnel of the duct, as in *Octochætus multipores* and other species. There are four sperm-sacs. The spermiducal glands are closely zig-zag, confined to their segments.

There are no penial chætæ, but transverse muscles are present in these segments.

The spermathecæ are provided with a single lobulated spherical diverticulum.

EXPLANATION OF PLATES XXII.-XXVI.

Plates XXII.-XXV.

The illustrations of the anatomy of the earthworms described in this paper are purely diagrammatic, indicating only the segmental position of the various organs, the worm being supposed to be slit up along the dorsal line and the body-wall pinned aside.

A group of three diagrams refer to each worm herein described. The left-hand diagram in each of the groups referring to a species represents the external features. The location of the various genital pores is represented as round black dots (if on a papilla this is left white), the clitellum is obliquely shaded, the tubercula pubertatis are vertically shaded.

In addition, the arrangement of the chætæ—labelled *a*, *b*, *c*, *d*—is indicated in two or more segments in each case, usually in the 5th and the 22nd; they are omitted in the remaining segments for clearness' sake. The true relative spacing of the chætæ is shown, except where they are very numerous.

The position of the nephridiopores is indicated by the small circles on one side of the figure.

The middle figure represents the alimentary canal and so much of the vascular system as is diagnostic. The latter is black. The gizzard is indicated by vertical shading, the œsophageal glands by more or less horizontal lines. The intestine is not represented as being constricted, which is, however, the case in most worms.

The right-hand figure shows the reproductive system. The gonads are in black. The sperm-sacs are dotted. The sac with penial chætæ when present is indicated, and the muscular duct of the spermiducal gland is transversely striped. The transverse muscles in the 18th segment are shown.

No attempt is made to give the relative sizes of the worms or of the various organs. Nor has it been considered necessary to label the various organs, since to any one who is familiar with the anatomy of any earthworm the structures here indicated will be sufficiently intelligible.

PLATE XXVI.

The Spermathecæ of the Earthworms described.

Fig. 1. Spermatheca of *Megascolex laingii.*
Fig. 2. „ *Notiodrilus aucklandicus.*
Fig. 3. *N. macquariensis.*
Fig. 4. *Plagiochæta sylvestris.*
Fig. 5. *P. lineatus* (of type example).
Fig. 6. *P. lateralis.*
Fig. 7. *P. rossii.*
Fig. 8. *P. ricardi.*
Fig. 9. „ *P. montana.*
Fig. 10. Penial chæta of *Notiodrilus aucklandicus.*
Fig. 11. *N. macquariensis.*
Fig. 12. *Plagiochæta sylvestris* (type).
Fig. 13. *P. lineatus* (type).

ART. XXXII.—*A List of the* Hymenoptera *of New Zealand.*

By P. CAMERON.

Communicated by Captain Hutton.

[*Read before the Philosophical Institute of Canterbury, 3rd September, 1902.*]

Family SIRICIDÆ.

Xiphydria.

Xiphydria, Latr., Gen. Ins. et Crust., iii., 304.

X. DECEPTA, Smith. *Derecyrta deceptus*, Smith, Trans. Ent. Soc., 1876, p. 474, pl. iv., fig. 6. *Xiphydria flavopicta*, Smith, *l.c.*, 1878, p. 1. *Brachyixiphus deceptus*, Kirby, Trans. Ent. Soc., 1881, p. 49.

Family CYNIPIDÆ.

Anacharis, Dal.

Anacharis, Dalman, Ann. Entomol., 1823, 95.

A. ZEALANDICA, Ashmead, Proc. Linn. Soc. New South Wales, 1900, 329.

Family TENTHREDINIDÆ.

Eriocampa, Hartig.

Eriocampa, Hartig, Die Fam. der Blattwespen und Holzwespen, 279.

ERIOCAMPA ADUMBRATA, Klug. *Tenthredo adumbrata*, Klug, Berl. Mag., viii., 64, 36. *Monostigia antipoda*, Kirby, Trans. Ent. Soc., 1881, p. 50.

A European introduction.

Family ICHNEUMONIDÆ.

Sub-family ICHNEUMONINÆ.

Ichneumon, L. s. str.

I. PYRASTIS, Cameron, Trans. N.Z. Inst., 1900, 115.
I. FREDERICI, Cameron, *l.c.*, 116.
I. RICCARDI, Cameron, *l.c* , 117.
I. WELLINGTONI, Cameron, *l.c.*, 117.
I. ACTISTA, Cameron, Manchr. Mem., 1898, 8.
I. HELMSI, Cameron, *l.c.*, 9.
I. ATARXIDIA, Cameron, *l.c.*, 13.
I. IXIA, Cameron, *l.c.*, 13.
I. COLENSII, Cameron, *l.c.*, 15.
I. URSULA, Cameron, *l.c.*, 16.
I. BROUNII, Cameron, *l.c.*, 17.
I. LEVDACUS, Cameron, *l.c.*, 19.
I. FALSUS, Cameron, *l.c.*, 18.
I. MACHIMIA, Cameron, *l.c.*, 20.
I. UTETES, Cameron, *l.c.*, 21.
I. THYELLMA, Cameron, *l.c.*, 22.
I. NOVA-ZEALANDICUS, Cameron, *l.c.*, 23.
I. DECORATORIUS, Fabricius, Syst. Ent., 333.
I. INSIDIATOR, Smith, Trans. Ent. Soc., 1876, 476.
I. DECEPTUS, Smith, *l.c.*, 477.
I. EXHILARATUS, Smith, *l.c.*, 477.
I. CONSANGUINEUS, Smith, *l.c.*, 476.
I. PLACIDUS, Smith, *l.c.*, 476.
I. CONSPIRATUS, Smith, *l.c.*, 476.
I. PERFIDIOSUS, Smith, *l.c.*, 475, pl. iv., f. 5.
I. HUTTONII, Kirby, Trans. Ent. Soc., 1881, 44.
These species require generic revision.
I. HERSILIA, Cameron, Manchr. Mem., 1898, 7.

Probolus, Wesmael.

Probolus, Wesmael, Mém. Acad. Brux., xviii., 1844, 150.

PROBOLUS LOTATORIUS, Fab. *Ichneumon lotatorius*, Fabricius, Syst. Ent., 330. *Priocnemis pascoei*, Kirby, Trans. Ent. Soc., 1883, p. 200. *Eristicus cinctus*, Ashmead, Proc. U.S. National Museum, xii., p. 389.

PROBOLUS INVECTUS, Smith. *Ichneumon invectus*, Smith, Trans. Ent. Soc. *Eristicus basilaris*, Ashmead, Proc. U.S. Nat. Museum, xii., p. 389.

PROBOLUS SOLLICITORIUS, Fab. *Ichneumon sollicitorius*, Fab., Syst. Ent., 332. *Eristicus apicalis*, Ashmead, Proc. U.S. Museum, xii., p. 388.

Amblyteles, Wesmael, 1844.

A. ZEALANDICUS, Cameron, Trans. N.Z. Inst., 1900, 108.
A. HUDSONI, Cameron, *l.c.*, 109.

Colobacis, Cameron, 1900.

C. FORTICORNIS, Cameron, Trans. N.Z. Inst., 1900, 110.

Degithina, Cameron, 1900.

D. BUCHANANI, Cameron, Trans. N.Z. Inst., 1900, 112.
D. CAROLI, Cameron, *l.c.*, 113.
D. DAVIDI, Cameron, *l.c.*, 114.
D. HECTORI, Cameron, *l.c.*, 114.

Zestocormus, Cameron, 1901.

Z. MELANOPUS, Cameron, Trans. N.Z. Inst., 1900, 119.

Dicœlotus, Wesmael, 1844.

D. STRIATIFRONS, Cameron, Manchr. Mem., 1898, 24.

Sub-family CRYPTINÆ.

Cryptus, Fabricius, 1804.

C. PENETRATOR, Smith, Trans. Ent. Soc., 1878, 2.

Mesostenus, Gravenhorst.

M. ALBOPICTUS, Smith, Trans. Ent. Soc., 1876, 477, pl. iv., f. 1.

Hemiteles, Gravenhorst.

H. DESTRUCTIVUS, Cameron, Manchr. Mem., 1898, 26.

Bathymetis, Förster.

B. ANTIPODA, Ashmead, Entomological News, 1900, 624.

Sub-family OPHIONINÆ.

Ophion, Gravenhorst.

O. INUTILIS, Smith, Trans. Ent. Soc., 1876, 478.
O. PUNCTATUS, Cameron, Manchr. Mem., 1898, 34.
O. FERRUGINEUS, Smith, Trans. Ent. Soc., 1878, 2.
O. PEREGRINUS, Smith, *l.c.*, 1876, 478.
O. SKELLONI, Kirby, Trans. Ent. Soc., 1881, 46.
O. INSULARIS, Kirby, *l.c.*, 46.

Paniscus, Gravenhorst.

P. PRODUCTUS, Brullé, Hist. Nat. des Ins., Hym., iv. P. *ephippiatus*, Smith, Trans Ent. Soc., 1876, 478.
P. FOVEATUS, Cameron, Manchr. Mem., 1898, 36.

Limnerium, Ashmead.

Limneria, Auct. præve.

L. ZEALANDICUM, Cameron, Manchr. Mem., 1898, 36.
L. HUDSONI, Cameron, Trans. N.Z. Inst., xxxiii., 105.

Sub-family PIMPLIDINÆ.

Rhyssa, Gravenhorst, 1829.

R. FRACTINERVIS, Vollenhoven, Tijd. Ent. (2), viii., 67, pl. iv., f. 1, 1*a*. *R. antipodum*, Smith, Trans. Ent. Soc., 1876, 479, pl. iv., f. 4.
R. CLAVULA, Colenso, Trans. N.Z. Inst., xvii., 158.

Allotheronia, Ashmead, 1900.

A. 12-GUTTATA, Ashmead, Proc. Linn. Soc. N.S.W., 351.

Lissopimpla, Kriechbaumer, 1889.

Xenopimpla, Cam.

L. SEMIPUNCTATA, Kirby, Trans. Ent. Soc., 1883, 202.

Lissonota, Gravenhorst.

L. FLAVOPICTA, Smith, Trans. Ent. Soc., 1878, 4.
L. ALBOPICTA, Smith, *l.c.*, 4.
L. MULTICOLOR, Colenso, Trans. N.Z. Inst., xvii., 159.
L. TINCTIPENNIS, Cameron, Manchr. Mem., 1898, 28.
L. RUBRIPLAGIATA, Cameron, Trans. N.Z. Inst., xxxiii., 106.

Euctenopus, Ashmead, 1900.

E. NOVA-ZEALANDICA, Ashmead, Proc. Linn. Soc. N.S.W., 1900, 351.

Sub-family TRYPHONINÆ.

Tryphon, Fullén, 1813.

T. OBSTRUCTOR, Smith, Trans. Ent. Soc., 1878, 4.

Mesoleptus, Gravenhorst, 1829.

M. MULLERI, Butler, Voy. "Erebus" and "Terror," Ins., 27, 46.
M. SYBARITA, Cameron, Manchr. Mem., 1898, 32.
M. COMPARATUS, Cameron, *l.c.*, 33.

Chorinacus, Holmgren, 1855.

C. FORTICEPS, Cameron, Manchr. Mem., 1898, 29.
C. NIGRIPES, Cameron, *l.c.*, 33.

Bassus, Fabricius.

B. LACTATORIUS,* Fabricius, Fab. Syst., Ins., i., 424. *B. generosus*, Cameron, Manchr. Mem., 1898, 31. *Scolobates varipes*, Smith, Trans. Ent. Soc., 1878, 3.

* Introduced.

[*Scolobates intrudens*, Sm., Trans. Ent. Soc., 1878, 3. Species doubtful; may belong to the *Ichneumonidæ* or to the *Braconidæ*.]

Family BRACONIDÆ.

Sub-family RHOGADINÆ.

Doryctomorpha, Ashmead, 1900.

D. ANTIPODA, Ashmead, "Entomological News," 1900, 630. Chatham Islands.

Rhogas, Nees, 1818.

R. PENETRATOR, Smith, Trans. Ent. Soc., 1878, 5.

Sub-family METEORINÆ.

Meteorus, Hal., 1835.

M. NOVA-ZEALANDICUS, Cameron, Manchr. Mem., 1898, 38.

Fhogra, Cameron, 1891.

F. RUBROMACULATA, Cameron, Trans. N.Z. Inst., xxxiii., 105.

Sub-family CHELONINÆ.

Ascogaster, Wesm., 1835.

A. CRENULATUS, Cameron, Manchr. Mem., 1898, 37.

Sub-family HELICONINÆ.

Schauinslandia,* Ashmead, 1900.

S. FEMORATA, Ashmead, "Entomological News," 1900, 627.
S. ALFKENII, Ashmead, *l.c.*, 628.
S. PALLIDIPES, Ashmead, *l.c.*, 628.

Sub-family OPIINÆ.

Diachasma, Förster, 1862.

D. CARPOCAPSÆ, Ashmead, Proc. Linn. Soc. N.S.W., 1900, 357.

Sub-family ALYSIINÆ.

Alysia, Latreille.

A. STRAMINEIPES, Cameron, Manchr. Mem., 1898, 37.

Asobara, Förster, 1862.

A. ANTIPODA, Ashmead, "Entomological News," 1900, 625. Ex Chatham Islands.

Sub-family DACNUSINÆ.

Dacnusa, Haliday, 1839.

D. SONCHIVORUS, Cameron.
Ex dipterous insect mines on *Sonchus oleraceus*.

* Ex Chatham Islands.

Family EVANIIDÆ.

Gasteruption, Latreille, Préc. Caract., 1796, 113.

Fœnus, Fab. Syst. Piez., 141.

G. PEDUNCULATUM, Schl. *Fœnus unguiculatus*, Smith, Trans. Ent. Soc., 1869, p. 480, pl. iv., f. 8. *Gasteruption pedunculatum* (? Westwood), Schletterer, Ann. k. k. natur. h. of Mus. Wien, 1890, p. 467.

Family CHALCIDIDÆ.

Sub-family TORYMINÆ.

Torymus, Dalman, 1820.

T. (CALLIMONE) ANTIPODA, Kirby, Trans. Ent. Soc., 1883, 202.

Sub-family EURYTOMINÆ.

Eurytoma (Illiger), Rossi.

E. OLEARIÆ, Maskell, Trans. N.Z. Inst., xxi., 255.

Aphobetus, Howard, 1896.

A. MASKELLI, Howard, Canadian Ent., xxviii., 166.

Sub-family APHELININÆ.

Pteroptrix, Westw.

P. MASKELLI, Ashmead, Proc. Linn. Soc. N.S.W., 1900, 346.

Sub-family EUPELMINÆ.

Eupelmus, Dal.

E. MESSENE, Walker, Mon. Chal., ii., 95; Kirby, Trans. Ent. Soc., 1881, 48.

Pteromalus, Swed.

P. LELEX,* Walker, Mon. Chal., ii., 95; Kirby, *l.c.*, 48.
P. IAMBE,* Walker, *l.c.*; Kirby, *l.c.*, 49.

Sub-family EULOPHINÆ.

Eulophus, Geoffroy.

E. ALBITARSIS, Ashmead, "Entomological News," 1900, 623.

Chatham Island. Is found also in Europe and North America.

Family PROCTOTRUPIDÆ.

Sub-family PROCTOTRUPINÆ.

Proctotrupes, Latreille, Préc. Car., 108.

P. MACULIPENNIS, Cameron, Manchr. Mem., 1888, p. 175.
P. INTRUDENS, Smith, Trans. Ent. Soc., 1878, p. 5.

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*Genus doubtful.

Sub-family Betylinæ.

Betyla, Cam.

Betyla, Cameron, Manchr. Mem., 1889, 13. *Tanyzonus,* Marshall, E.M.M., 1892.

B. fulva, Cameron, *l.c.;* Hudson, Trans. N.Z. Inst., xxv., 164. *Tanyzonus bolitophilæ,* Marshall, *l.c.*

Sub-family Diaprinæ.

Diapria, Latr.

D. coccophaga, Maskell, Trans. N.Z. Inst., xi., 228.

Spilomicrus, West.

S. quadriceps, Smith, Trans. Ent. Soc., 1878, 6.

Sub-family Mymarinæ.

Mymar, Curt.

M. crinisacri, Quail, Trans. N.Z. Inst., xxxiii., 153.

Sub-family Bethylinæ.

Sierola, Cam., 1881.

S. antipoda, Ashmead, Proc. Linn. Soc. N.S.W., 1900, 328; *cf.* Fauna Hawaiiensis, Hymen., 286.

Family SPHEGIDÆ.

Rhopalum, Steph.

Rhopalum (Kirby), Stephens, Syst. Cat., 1829.

R. carbonarium, Smith. *Crabro carbonarius,* Smith, Cat. Hym. Ins., iv., p. 424.
R. perforatum, Smith, Trans. Ent. Soc., 1876, p. 483.
R. albipes, Smith, Trans. Ent. Soc., 1878, p. 7.
R. cora, Cam. *Crabro cora,* Cameron, Manchr. Mem., 1888, p. 181.

Gorytes, Latreille.

Gorytes, Latreille, Hist. Nat., xiii., 308.

G. carbonarius, Smith, Cat. Hym. Ins., iv., p. 366. *G. trichiosoma,* Cameron, Manchr. Memoirs, 1888, p. 180.

Tachytes, Pz.

Tachytes, Panzer, Krit. Revis., ii., 129.

T. nigerrimus, Smith, Cat. Hym. Ins. B.M., iv., p. 302. *Astata nigerrima,* White, Voy. "Erebus" and "Terror," Ins., pl. vii., f. 14.
T. sericops, Smith, Cat. Hym. Ins. B.M., iv., p. 302.
T. depressus, Saussure, Reise d. "Novara," Hym., p. 69.
T. helmsi, Cameron, Manchr. Memoirs, 1888, p. 182.

Pison, Spinola.

Pison, Spinola, 1808. *Taranga*, Kirby, Trans. Ent. Soc., 1883, p. 201.

P. PRUINOSUS, Cameron, Manchr. Memoirs, 1898, p. 44.
P. MOROSUS, Smith, Cat. Hym. Ins. B.M., iv., p. 317.
P. TUBERCULATUS, Smith, Trans. Ent. Soc., 1869, p. 296.
P. DUBIUS, Kirby. *Taranga dubia*, Kirby, Trans. Ent. Soc., 1883, p. 201.

Family POMPILIDÆ.

Pseudagenia, Kohl, Verh. z.-b. Ges., Wien, 1884, p. 42.

P. HUTTONI, Cam. Manchr. Memoirs, 1898, p. 49.

Salius, Fab., 1804.

S. MONACHUS, Smith. *Pompilus monachus*, Smith, Cat. Hym. Ins., iii., p. 164.
S. CARBONARIUS, Sm. *Pompilus carbonarius*, Smith, *l.c.*, p. 162.
S. NITIDIVENTRIS. *Priocnemis nitidiventris*, Smith, Trans. Ent. Soc., 1878, p. 6.
S. MARGINATUS, Smith. *Priocnemis marginatus*, Smith, Trans. Ent. Soc., 1876, p. 483, pl. iv., f. 2.
S. CONFORMIS, Sm. *Priocnemis conformis*, Trans. Ent. Soc., 1876, p. 482.
S. TRIANGULARIS, Cam. Manchr. Memoirs, 1898, p. 45.
S. DILIGENS, Smith. *Priocnemis diligens*, Smith, Trans. Ent. Soc., 1876, p. 483, pl. iv., fig. 3.
S. WAKEFIELDI, Kirby. *Priocnemis wakefieldi*, Kirby, Trans. Ent. Soc., 1881, p. 39.
S. FUGAX, Fab. *Sphex fugax*, Fab., Syst. Ent., p. 350. *Priocnemis maculipennis*, Smith, Trans. Ent. Soc., 1876, p. 482.
S. HUTTONI, Kirby. *Priocnemis huttoni*, Kirby, Trans. Ent. Soc., 1883, p. 199.
S. XENOS, Kirby. *Priocnemis xenos*, Kirby, *l.c.*, 200.
S. BROUNI, Grib. *Agenia brouni*, Bull., Ent. Ital., xvi., 280.

Family THYNNIDÆ.

RHAGIGASTER,* Guérin, 1838.

R. NOVARÆ, Saussure, Hym. "Novara" Reise, 112.

Family FORMICIDÆ.

Lasius, Fabricius, 1804.

L. ADVENA,† Smith, Trans. Ent. Soc., 1862, 53.
L. ZEALANDICA,† Smith, *l.c.*, 1878, 6.

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* Requires confirmation as native.
† Genus doubtful.

Prenolepis.

P. LONGICORNIS,* Latr., Hist. Fourm., 113.

Sub-family PONERINÆ.

Ponera, Latreille, 1804.

P. CASTANEA, Mayr., Hym. "Novara" Reise.

Ectatomma, Smith, 1858.

E. BROUNII, Forel, Mitt. Schw. Ent. Ges., 1892, 330.

Discothyrea, Rogers, 1863.

D. ANTARCTICA, Emery, Trans. N.Z. Inst., xxvii., 635.

Amblypone, Erichson.

A. CEPHALOTES, Smith, Trans. Ent. Soc., 1876, 490.
A. SAUNDERSI, Forel, Mitt. Schw. Ent. Ges., 1892, 336.

Sub-family MYRMICINÆ.

Orectognathus, Smith, 1854.

O. ANTENNATUS, Smith, Trans. Ent. Soc. (2), ii., 228, pl. xxi., fig. 9.
O. PERPLEXUS, Smith, Trans. Ent. Soc., 1876, 491.

Strumigenys, Smith, 1861.

S. ANTARCTICA, Forel, Mitt. Schw. Ent. Ges., 1892, 338.

Huberia, Forel, 1890.

H. STRIATA, Smith, Trans. Ent. Soc., 1876, 481; Hutton, Trans. N.Z. Inst., iv., 304.

Monomorium, Mayr., 1855.

M. FULVUM, Mayr., Reise d. "Novara," Form., 93, pl. iii., f. 25.
M. NITIDUM, Smith, Trans. Ent. Soc., 1876, 480.
M. SUTERI, Forel, Mitt. Schw. Ent. Ges., 1892, 340.
M. SMITHII, Forel, *l.c.* 342.

Aphænogaster, Mayr., 1852.

A. ANTARCTICUS, Smith, Cat. Hym. Ins., vi., 167.

Family ANTHOPHILA.

Prosopis, Fabricius, Syst. Piez, 293 (1804).

P. AGILIS, Smith, Trans. Ent. Soc., 1876, p. 484.
P. RELEGATUS, Smith, *l.c.*, p. 485.
P. CAPITOSUS, Smith, *l.c.*, p. 485.
P. LÆVIGATUS, Smith, Cat. Hym. Ins. B.M., ii., p. 420.

* Introduced.

P. SULCIFRONS, Cameron, Manchr. Memoirs, 1895, p. 51.
P. INNOCENS, Cameron, *l.c.*, p. 52.
P. VICINA, Sichel, Reise d. "Novara," Hym., p. 143.

Halictus, Latr.

Halictus, Latreille, Hist. Nat., xiii., 364.

H. SORDIDUS, Smith, Cat. Hym. Ins., i., 56.
H. FAMILIARIS, Smith, Trans. Ent. Soc., 1876, 486.
H. HUTTONI, Cameron, Trans. N.Z. Inst., xxxii., 17.

Dasycolletes.

Dasycolletes, Cat. Hym. Ins.

D. HIRTIPES, Smith, Trans. Ent. Soc., 1878, p. 7.
D. VESTITUS, Smith, *l.c.*, 1876, p. 485.
D. PURPUREUS, Smith, Cat. Hym. Ins. B.M., i., p. 15.
D. METALLICUS, Smith, *l.c.*, p. 15. *Andrena trichopus,* White, Voy. "Erebus" and "Terror," Ins., pl. vii., fig. 12.

Leioproctus.

Leioproctus, Smith, Cat. Hym. Ins. B.M., i., p. 9.

L. IMITATUS, Smith, *l.c.*, p. 9.

Lamprocolletes.

Lamprocolletes, Smith, Cat. Hym. Ins. B.M., i.

L. FULVESCENS, Smith, Trans. Ent. Soc., 1876, p. 486.
L. OBSCURUS, Smith, Cat. Hym. Ins. B.M., i., p. 11.

ART. XXXIII.—*On the Marine Mollusca of Totaranui Bay, Nelson.*

By Professor JAMES PARK, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 13th May, 1902.*]

TOTARANUI is situated on the shores of Tasman Gulf, some forty miles north-west of Nelson, and about midway between that place and Collingwood. A crescent-shaped beach of golden sand nearly a mile long and terminating at the ends against bold headlands of granite crowned with dark evergreen forest, a low terrace and shallow lagoon behind the beach, undulating fern-clad foot-hills beyond the flat, and a background of high forest-covered ranges, form, with a perfect climate, one of the most charming and picturesque spots in a region famed for the beauty of its summer retreats.

The beach is steep, except at the north end, and composed of very coarse quartz sand and broken shells. It is sheltered from all winds except from the north-east, east, and south-east.

Excluding the recent alluvia forming the flat around the lagoon, only one rock-formation is represented in this district—namely, a crumbling grey-coloured granite, which is generally extremely coarse in texture. The feldspars of this granite exist mostly in large tabular crystals commonly from ½ in. to 1 in. long, but often reaching a length of 3 in. or more. The quartz is the predominant constituent. It occurs in large grains and irregular aggregates, which become prominent on all weathered and water-worn surfaces, thereby imparting a rough and rugged appearance to all the rocky headlands facing the sea. In such a coarse-grained rock the mica occupies a very subordinate place, and in most parts is hardly perceptible to the eye.

On the coast-line between Totaranui and Anapai going north, and between Totaranui and Awaroa going south, the granite is traversed with veins of grey-coloured crypto-crystalline quartz, varying from a mere thread to 3 in. or 4 in. in thickness. A mile before the Awaroa River is reached the grey granite is displaced by a wide belt of pink or reddish-coloured granite of intense hardness, and admirably adapted for a building-stone. This belt of pink granite is more than 100 yards wide, and in the direction of Awaroa is followed by the grey granite, which thence stretches southward for many miles without interruption.

This granite is a rock of great antiquity. At Takaka and Riwaka it is seen to be associated with crystalline limestones and quartzites of Lower Silurian age, and the geological considerations detailed in my report on the geology of Collingwood County* afford good reason for the belief that the rocks in this and the surrounding region are the most ancient in New Zealand.

During a three-months residence at this beautiful place in the summer of 1901–1902 the writer collected 149 different species of *Mollusca*, including only those whose soft parts are protected with a shell or hard covering. This comparative poverty in molluscous life is doubtless due in part to the extremely coarse and ever-shifting sands, the absence of beach muds and fine sediments, and the exposed position of the enclosing rocky headlands.

On the other hand, it must not be forgotten that Totaranui is but a small nook in the great gulf contained between Cape Farewell Spit and D'Urville Island, and it is certain that a

* Geol. Rept. and Explorations, 1888–89.

search of the adjoining bays, which in many instances present a great variety of conditions, would discover a much larger assemblage of marine shells than that enumerated in this paper.

In this collection the *Brachiopoda* are represented by three species—namely, *Terebratella rubicunda* (rare), *Magas evansi* (rare), and *Rhynchonella nigricans* (very rare). Of the latter only one example was found.

Among the fifty-two Conchifers the most common genera are *Mytilus*, *Chione*, *Venus*, *Tapes*, *Vola*, *Mactra*, *Mesodesma*, and *Pecten*.

The *Polyplacophora* are singularly scarce, only two species being found—namely, *Chiton quoyi* and *Ornithochiton undulatus*—and examples of these are by no means common.

The most prominent genera of *Gasteropoda* are *Patella*, *Haliotis*, *Turbo*, *Diloma*, *Ancillaria*, *Natica*, *Trophon*, *Murex*, *Struthiolaria*, *Turritella*, and *Amphibola*.

The *Cephalopoda* have only one representative—namely, *Spirula pironii*.

It may be noted in passing that the *Echinodermata* were observed to be represented by four species—namely, *Evechinus chloroticus*, *Arachnoides placenta*, *Echinocardium zealandicum*, and *Echinobrissus recens*. On a few occasions, after heavy south-east weather, the latter was thrown on the shore in thousands, but, being so fragile, perfect specimens were not often found.

BRACHIOPODA.

Terebratella rubicunda, *Sowerby*.
Magas evansi, *Davidson*.
Rhynchonella nigricans, *Sowerby*.

LAMELLIBRANCHIATA.

Ostrea purpura, *Hanley*.
" discoidea, *Gould*.
Anomia alectus, *Gray*.
Pecten zealandicus, *Gray*.
" gemmulatus, *Reeve*.
Vola laticostatus, *Gray*.
Lima angulata, *Sowerby*.
Mytilus latus, *Chemnitz*.
" magellanicus, *Lamarck*.
Modiola areolata, *Gould*.
Crenella impacta, *Hermann*.
Pinna zealandica, *Gray*.
Pectunculus laticostatus, *Quoy and Gaimard*.
" striatularis, *Lamarck*.
Barbatia decussata, *Sowerby*.
Tapes intermedia, *Quoy*.

Chione stuchburyi, *Gray*.
" yatei, *Gray*.
" costata, *Q. and G.*
" mesodesma, *Quoy*.
Venus oblonga, *Hanley*.
Lucina divaricata, *Linne*.
Pythina stowei, *Hutton*.
Artemis subrosea, *Gray*.
" australis, *Gray*.
Cardium striatulum, *Sowerby*.
Cardita zealandica, *Potiez and Michaud*.
" australis, *Q. and G.*
Leda concinna, *Adams*.
Nucula nitidula, *Adams*.
" strangei, *Lamarck*.
Diplodonta globularis, *Lamarck*.
" zealandica, *Gray*.
Barnea similis, *Gray*.
Psammobia lineolata, *Gray*.
" strangei, *Gray*.
Venerupis reflexa, *Gray*.
Tellina deltoidalis, *Lamarck*.
" alba, *Q. and G.*
" sublenticularis, *Sowerby*.
Mesodesma novæ-zealandiæ, *Chemnitz*.
" lata, *Deshayes*.
" ventricosa, *Gray*.
" spissa, *Reeve*.
Mactra discors, *Gray*.
" æquilateralis, *Deshayes*.
Vanganella taylorii, *Gray*.
Corbula zealandica, *Q. and G.*
Crassatella obesa, *Adams*.
Zenatia acinaces, *Q. and G.*
Myodora striata, *Q. and G.*
Solenella australis, *Q. and G.*

Polyplacophora.

Chiton quoyi, *Deshayes*.
Ornithochiton undulatus, *Q. and G.*

Gasteropoda.

Bulla quoyi, *Gray*.
Haminea zealandica, *Gray*.
Siphonaria sipho, *Sow.*
" australis, *Quoy*.
Ianthina iricolor, *Reeve*.

Trophon stangeri, *Gray.*
" ambiguus, *H. and J.*
" dubius, *Hutton.*
" incisus, *Gould.*
" paivæ, *Crosse.*
Murex zealandicum, *Q. and G.*
" octoganus, *Q. and G.*
Cassis pyrum, *Lam.*
Scalaria zelebori, *Frauenfeld.*
Voluta gracilis, *Swainson.*
" pacifica, *Lam.*
" pacifica *var.* nodosa.
Struthiolaria australis, *Gmelin.*
" papulosa, *Martyn.*
Ancillaria australis, *Sow.*
" pyramidalis, *Reeve.*
Natica zealandica, *Q. and G.*
Drillia novæ-zealandiæ, *Reeve.*
" cheesemani, *Hutton.*
" buchanani, *Hutton.*
Lunatia australis, *Hutton.*
Daphnella cancellata, *Hutton.*
Polytropa striata, *Martyn.*
" textiliosa, *Lam.*
" scobina, *Q. and G.*
Cominella lurida, *Philippi.*
" maculata, *Martyn.*
" funerea, *Gould.*
" testudinea, *Chem.*
Tritonium spengleri, *Chem.*
Neptunea zealandica, *Q. and G.*
" dilatata, *Q. and G.*
" nodosa, *Martyn.*
" caudata, *Q. and G.*
Mitra rubiginosa, *Hutton.*
Euthria lineata, *Chem.*
Purpura haustrum, *Martyn.*
Acus kirki, *Hutton.*
Nerita atrata, *Lam.*
Melanopsis strangei, *Reeve.*
Chemnitzia zealandica, *Hutton.*
Trichotropis inornata, *Hutton.*
Cerithidea nigra, *H. and J.*
" bicarinata, *Gray.*
Hipponyx australis, *Q. and G.*
Haliotis iris, *Myrtyn.*
" rugoso-plicata, *Chem.*
" gibba, *Philippi.*

Patella argyropsis, *Lesson.*
„ inconspicua, *Gray.*
„ magellanica, *Martyn.*
„ reevei, *Hutton.*
„ radians, *Gmelin.*
„ denticulata, *Martyn.*
„ pholidota, *Lesson.*
„ stellifera, *Chem.*
„ rubiginosa, *Hutton.*
„ stellularia, *Quoy.*
Parmophorus unguis, *Linne.*
Euchelus bellus, *Hutton.*
Trochita scutum, *Lesson.*
„ novæ-zealandiæ, *Lesson*
Crypta costata, *Q. and G.*
„ unguiformis, *Sow.*
Cantharidus pallidus, *H. and J.*
„ purpuratus, *Martyn*
„ zealandicus, *Adams*
„ iris, *Gmelin.*
„ huttonii, *Smith.*
Littorina cærulescens, *Lam.*
Monilea egena, *Gould.*
Cladopoda zealandica, *Q. and G.*
Emarginula striatula, *Q. and G.*
Tugali parmophoidea, *Q. and G.*
Turritella rosea, *Q. and G.*
Rotella zealandica, *H. and J.*
Anthora tuberculata, *Gray.*
Trochocochlea subrostrata, *Gray*
Calcar imperialis, *Chem.*
Gibbula sanguinea, *Gray.*
Turbo smaragdus, *Martyn.*
Zizyphinus punctulatus, *Martyn.*
„ granatum, *Chem.*
Diloma æthiops, *Gmelin.*
„ nigerrima, *Chem.*
„ gaimardi, *Philippi.*
Amphibola avellana, *Gmelin.*

Cephalopoda.

Spirula pironii, *Lamarck.*

ART. XXXIV.—*On a New Species of* Psyllidæ.

By GEORGE R. MARRINER, Assistant, Biological Laboratory, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

Plates XXXIII. and XXXIV.

THE *Psyllidæ* are a family of insects belonging to the order *Homoptera,* and are more closely allied to the *Aphididæ* than to the *Coccidæ.* The only species that have been reported from New Zealand are, as far as I can ascertain, several described by the late Mr. W. M. Maskell in 1889.* Several entomologists of Europe and America have studied this group—namely, Dr. F. Löw, of Germany; Mr. J. Scott, of England; M. V. Slingerland, of the United States of America; and E. Witlaczil, of Austria.

About the beginning of 1902 a branch of the so-called matipo (*Pittosporum tenuifolium*) covered with numerous scale-insects was sent to me. On examining them I found them to be a species of *Psyllidæ,* which appears to be intermediate between two species described by Mr. Maskell. The following is the specific description:—

Trioza alexina, sp. nov. Plates XXXIII. and XXXIV.

Imago.—Eyes not very prominent, but large; the inner edges form an obtuse angle. The ocelli (Plate XXXIII., fig. 4), consisting of a lens and a quantity of brown pigment, are three in number, one at the angle of each eye and one in the front of the head (Plate XXXIII., fig. 3). The fore wing (Plate XXXIII., fig. 1) is more like that of *Trioza panacis* in venation but that of *Trioza pellucida* in shape, but resembles the typical wing of the genus more closely than either of them.

The primary stalk of the veins (Plate XXXIII., fig. 1, AB) divides directly into three main branches at the point B—viz., (1.) An upper main branch, the stalk of the subcosta (BF), which again divides into two about halfway (F) to the margin. A shorter branch (FG) runs on to the margin, and a longer vein, the radius (FH), runs towards the apex of

* Trans. N.Z. Inst., 1889.

the wing, and reaches the costal vein about seven-eighths of the length of the wings. (2 and 3.) The lower main branches form the upper and lower main branches of the cubitus, which branches directly from the primary stalk at B. The upper main branch of the cubitus divides again at C, but neither branch is a continuation of the main branch. The lower main branch of the cubitus divides at N, a longer and convex branch reaches the margin at K, and a shorter branch reaches the margin at L.

Running from the primary stalk to the lower margin of the wing is an indistinct vein (AM) called the "clavus." In the areas between the branches of the cubitus—namely, DE, EK, KL—are three small triangular markings, composed of very small dots; on the veins of the wing are some very short fine hairs.

The hind wing (Plate XXXIII., fig. 2) is larger in comparison with the fore wing than in either *Trioza panacis* or *Trioza pellucida*. The veins are only marked by rows of large dots, and the whole wing is covered with very small dots. The rostrum is pointed and blackened at the tip, ending in the male with three setæ (Plate XXXIII., fig. 9), which are entirely absent in the female.

Length, about 2·25 mm.

Pupa.—Head generally depressed behind. Eyes large, and of a very dark brown colour. Ocelli three, situated as in the adult. The fringe is very strongly developed, but the individual rods are longer and closer together than in *T. panacis* or *T. pellucida*, and the cups are more or less simply thickenings of the lower portions (Plate XXXIV., fig. 2). The anal ring is ventral, and closely resembles that of *Trioza panacis*.

Length, about 1·75 mm.

Hab. I have found it on *Pittosporum tenuifolium*, where the pupæ lie in little pits both on the ventral and dorsal surfaces of the leaf. Its presence is indicated by the presence of large quantities of a white semi-transparent excretion termed "manna," which fills up the hollows of the leaves, and in windy weather falls to the ground, giving the appearance of a light fall of snow.

Adult Female.—Generally of a light-yellow colour, with a slight green tint which becomes darker during life, probably due to the green food showing through the semi-transparent skin. Head and thorax not so green as the abdomen. Genitalia are of a dark-brown colour, especially at the tips. The length, including genitalia, about 2·25 mm., and expanse of wings 7 mm. At the posterior and ventral surface of the thorax is a short blunt projection (Plate XXXIII., fig. 7, G), found also in the male, but its function seems to be unknown.

The head is broader than long, concave in front and depressed behind. The lower and front portion is prolonged into two conical projections, with numerous hairs. The rostrum is situated on the ventral surface of the thorax, and has a black pointed tip. The female has no setæ on the rostrum. Wings are large and membranous, and arch over and extend beyond the abdomen. Antennæ of ten joints (Plate XXXIII., fig. 8), the third joint being no thicker than the fourth. The first two joints are short, round, and scaly; third joint is longest; last joint is dilated and of a dark colour, with two unequal spines on its extremity. Legs are slender; tibia has numerous small spines on distal end, but in the third pair of legs these are partly replaced by four black conical projections. Tarsus is double-jointed, the second joint having two hooks or spines and a sucker on its distal end. Abdomen has a conspicuous yellow mass (Plate XXXIII., figs. 6, 7), probably corresponding to the pseudovitellus* of the pupa. The anus is situated on the dorsal surface some distance in front of the genital organs. The genitalia are larger in comparison with the abdomen than in *Psylla pyricola*, and are of a dark-brown colour, especially at the tips. Genitalia consist of three plates (Plate XXXIII., fig. 6)—the upper genital plate (A), the lower genital plate (D), and, close to the upper genital plate, a third plate (Plate XXXIII., fig. 6, B) called by Witlaczil the "main rod." Between this and the lower genital plate is a very transparent roundish lobe called the egg-sheath (C).† Viewed sideways the upper genital plate is longer than the lower; all except the egg-sheath are sharply pointed, with numerous hairs scattered about.

Adult Male.—This is very similar to the female, but the rostrum has three setæ, which are entirely absent in the female. The anus (Plate XXXIII., fig. 7, H) is situated on top of the upper genital plate instead of on the abdomen itself, as in the female. Genitalia (Plate XXXIII., fig. 7): The lower genital plate (B) is large and round, and forms the end of the body. It is prolonged upwards to form a pair of claspers (C). The upper genital plate is about as broad as it is long, and, like the remainder of genital organs, stands up almost at right angles from the body. Penis (E) is long and doubled back on itself at D, and provided with a hook at the end. Running through the penis is a duct (K). Having mounted two specimens during copulation, I find the arrangements of the organs are as follows: The claspers of the male grasp the lower plate of the female; the upper plate of the male clasps the upper

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* Witlaczil.

† I am a little doubtful about the homologies of the two portions last mentioned.

plate of the female; the penis, which is at other times doubled back on itself, is extended to its full length, and passes in between the "main rod" and the lower plate.

The *pupa* is about 1·75 mm. in length and 1·25 mm. in breadth, not counting the fringe. The head and thorax are more or less fused together; abdomen well marked and round. The pupa is almost stationary, but sometimes moves about slowly, especially when food is scarce. General colour is a light-yellow. Eyes large, facetted, but not prominent (Plate XXXIV., fig. 1). Ocelli, three. Legs are thick and broad, the distal end provided with a sucker, two hooks, and a spine. Rostrum (Plate XXXIV., fig. 5) is rounded at base and conical at the top, which is of a dark colour. A long seta runs from the tip backwards, and divides into two; this runs forwards and forms a complicated system of setæ, which appear to vary very much in different specimens. The anal ring is on the ventral surface; and, as I have seen in several of my specimens a small anal ring forming inside the old one, it seems as if new ones are formed as the animal increases in size.

The greater part of the white excretion found with the insects is excreted by the pupa through the anal ring, but small masses are also excreted by the imago. It appears to be a semi-transparent bag full of a transparent fluid which hardens when exposed to the air.

The whole body of the pupa is covered with a transparent shield, in appearance very much like a very small tortoise-shell. On the outer edge is a thick fringe of fine, long, transparent threads, very much like fine glass tubing. The fringe appears to stick to the leaf, and so hold the pupa in its place. The whole animal, with its fringe, can be hardly seen with a naked eye when on the leaf, but under the microscope it presents a very beautiful appearance.

Under the shield the wings can be seen forming, and when ready the imago ruptures the shield and emerges as the adult insect, except that the wings are still folded. Some entomologists state that the pupa changes its shape as it grows. With the exception of the wings forming and the general size increasing, I have seen no changes, though I had several batches of live insects and pupæ under a glass bell jar. I have been unable to find either the eggs or the larvæ.

EXPLANATION OF PLATES XXXIII. AND XXXIV.

Trioza alexina, sp. nov.

Plate XXXIII.

Fig. 1. Fore wing of adult insect—
AB. Primary stalk.
BF. Stalk of subcosta.
FH. Radius.
BC. Main upper stalk of cubitus.
BN. Main lower stalk of cubitus.
CD, CE. Secondary branches of BC.
NK, NL. Secondary branches of BN.
HM. Clavus.

Fig. 2. Hind wing of adult insect.

Fig. 3. Head of adult insect—
O. Ocelli.
A. Anterior projections.

Fig. 4. Ocellus of adult insect—
A. Lens.
B. Pigment.

Fig. 5. Hind leg of adult insect—
A. Conical projection.
B. Hooks and sucker.

Fig. 6. Abdomen of female--
A. Upper genital plate.
D. Lower genital plate.
C. Egg-sheath.
B. "Main rod."
E. Anus.

Fig. 7. Abdomen of male insect—
A. Upper genital plate.
B. Lower genital plate.
C. Claspers of B.
E. Penis.
D. Hinge of penis.
K. Duct running through penis.
H. Anus on upper genital plate.
G. Spur.

Fig. 8. Antenna of adult insect.

Fig. 9. Rostrum of adult male.

Plate XXXIV.

Fig. 1. Pupa—
A. Fringe.
B. Wing-covers.
C. Rudimentary wings.
D. Pseudovitellus glands.
O. Ocelli.

Fig. 2. Fringe (much enlarged)—
A. Cups.

Fig. 3. Leg of pupa.

Fig. 4. Anal ring of pupa.

Fig. 5. Rostrum of pupa, showing one of the many arrangements of the setæ.

All drawings greatly enlarged.

Art. XXXV.—*Notes on the Whitebait of New Zealand.*

By A. J. MacKenzie, Curator, Kanieri Lake Fish-hatchery, Westland.

Communicated by Sir J. Hector.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

I have seen a notice in the *Otago Witness* of a paper read at a meeting in Wellington about New Zealand whitebait, the writer contending that whitebait were the young (or fry) of *Galaxias attenuatus*. This is a question I have been taking a considerable interest in for some time, and as I have been experimenting with whitebait at the hatchery the following may prove of interest, and assist to solve the question of what

they really are. My opinion is that they are a distinct species, and not the fry (or young) of another fish. Of course, the whitebait should not be confused with the young smelt, a native fish that much resembles whitebait, but grows considerably larger, some of them growing to 8 in. or 10 in. in length.

During the last whitebait season Mr. James King, secretary of the Westland Acclimatisation Society, obtained a quantity of whitebait from the Hokitika River and forwarded them to me at the hatchery. I received them on the 21st November, 1901, and have had them in the rearing-boxes till the present time. They had the same treatment as the trout-fry, and throve very well, hardly any of them dying. I occasionally put a handful of salt in their water. They increased a little in size—a shade longer and filled out more. About the 10th March, 1902, I thought they were showing signs of developing ova, and on examination I found such to be the case; and on the 24th March they were nearly all carrying ova or milt. About the end of March and the first week in April a few of them died and burst open, and on examining them I found them crammed with ova. I concluded they died through inability to spawn in the box, the conditions not suiting them. I stripped (or spawned) a few of them, but they are too delicate to handle with success. I am trying to get them to spawn naturally in a box I have prepared for them, and to artificially fertilise the ova and hatch it; but I am doubtful if I can make a success of it with the appliances I have.

During the season whitebait run up the rivers of Westland in countless numbers, and gradually work their way up the streams, creeks, and small runs of water until they are pretty well dispersed, and it becomes very difficult to find them in the streams. I think they run up the streams and develope their ova in the fresh water, and after spawning return to the sea again. A few months after their appearance running up streams they may be noticed drifting down stream again in small numbers, perhaps three or four together, or sometimes as many as a dozen.

I am sending a few specimens of the whitebait, both male and female, and also some ova, preserved in formalin. The ova can be seen in the females quite distinctly through the skin of the belly. I would like to have them examined by some of the members and to hear their views on the subject, and any ideas they may have as to carrying out the experiment of hatching the ova. If practicable, I would be pleased to try them and let you know the result.

ART. XXXVI.—*Notes on the New Zealand Whitebait.*

By E. GIBSON.

Communicated by Sir J. Hector.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

HEARING that the curator of the Westland Acclimatisation Society had forwarded specimens of whitebait and ova for discussion at the institute, I am also forwarding specimens to see how they tally with other experience.

I have heard conflicting stories as to what whitebait really is. Some say they have kept them till they have grown into mullet, and as I was curious to see how many different kinds of fishes could be got out of the whitebait I thought to try for myself, so I got some and put them into a wooden box, but they died off. That was in 1890.

The next year I tried another lot, and this time I put them in glass jars and kept them until the middle of January, when on a hot day I forgot to shade them, and on coming home at night I found them all dead. I then made a concrete tank to have ready for next year, and when the season came round I got another supply and put them in the tank, and kept them well supplied with creek-water from a swamp. They got on fine until about August of the next year, when they died. I noticed that they were bad with a fungus, so I gave it up.

Next year, as the tank was there, I tried again; but this time the idea struck me that, as the whitebait comes out of the salt water, the old fish must go into the sea again to spawn, so when the season came round I gradually changed the water till in August and September they were in all sea-water. Then I changed the water again till October, and they were back again into fresh water. In this manner they throve well, and I kept them, and next season changed the water to salt again, and then back to fresh the third year, but they still remained the same. They are what we call "cowfish" or "inanga." I send three samples. The second-sized one in the spirits is after it came through the first sea-bath, and getting on for two years old. The largest one is after the next year's salt bath. The smallest one was put in spirits the following season. You will observe that they have have all come out brindled when immersed in spirits.

I hope this will be of some interest to the Wellington Philosophical Society.

NOTE.—Some time ago I forwarded to you some whitebait which you thought differed from those forwarded by Mr. A. J. MacKenzie. There is a little fish that comes up at the end of the whitebait season. They come for two or three days, and that finishes the season. They came up last season in millions, and are about $\frac{7}{8}$ in. long and $\frac{3}{32}$ in. deep.

Art. XXXVII.—*Notes on the New Zealand Whitebait.*

By Sir J. Hector.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

The question of the true nature of the so-called "New Zealand whitebait" has been so fully worked out and published that it is hardly necessary to say more about it. It belongs to the genus *Galaxias*, and is closely allied to the pike family (*Esocidæ*), and has no relation to the herrings of which the English whitebait is either the young fry or perhaps a separate species belonging to the genus *Clupea;* nor does it belong to the *Salmonidæ*, which in New Zealand is represented by (1) *Retropinna*, or "inanga" of the Maoris, and "smelt" of the settlers; and (2) by the "grayling" of the settlers, or "upokororo" of the Maoris (*Prototroctes oxyrhynchus*). All these fish ascend rivers, but they descend perhaps for breeding purposes to the tidal waters. Their history in this stage is still very obscure.

We thus have in our rivers: (1.) Grayling, or upokororo (*Prototroctes oxyrhynchus*), which is a game fish, taking fly-hooks, and growing to 14 in. in length, and ascending high up in the rivers at certain seasons in large schools. (2.) Smelt: This delicate fish is common only in estuarian water. Length from 5 in. to 12 in. There are probably two species (*Retropinna richardsoni* and *Osmerus eperlanus*). (3.) *Galaxias*,* so-called minnow of New Zealand, but, as above stated, allied to the pike of England (*Esox lucius*). Of this minnow there are probably several species.

The following are my notes on these fishes, published in 1870, but now out of print:—

The fresh waters of New Zealand are inhabited by only a few kinds of fish as compared with most other countries, and they are mostly of small size. Nevertheless, from their abundance at certain seasons, some species are of considerable importance as sources of food, and in a few cases possess more interest for the angler than is usually conceded to them. The two first species I have to mention deserve the attention of observers from their close affinity to the salmon and trout, of which the latter are now being rapidly acclimatised in the streams throughout the colony.

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* Hector, vol. ii., 402; Hutton, vol. xxviii., 314; Powell, vol. 34, 417; Clarke, vol. xxxi., 78.

Upokororo.

This is the native name of the grayling (*Prototroctes oxyrhynchus*), a fish that has been long familiar to the settlers in certain districts, but which does not appear to have been obtained by any of the earlier collectors of the fishes of New Zealand, and remained undescribed till last year (1869), when specimens were forwarded by the Westland Naturalists' Society to Mr. Frank Buckland, who eventually requested Dr. Günther's opinion about them. He recognised it to be a closely allied species to a fish from the fresh waters of Australia, discovered in 1862, and which he had placed in the same family with a salmonoid fish (*Haplochiton*) that inhabits the cold fresh waters of Tierra del Fuego, the Falkland Islands, and the southern parts of the American Continent.

Respecting the relationship of these genera to each other, Dr. Günther states that the Australian and New Zealand fish stand in the same relation to those in South America as the genus *Coregonus* (of which the whitefish of the American lakes and the vendace of Scotland are examples) does to the true salmon, and that, "however the southern *Haplochitonidæ* may differ from the *Salmonidæ* in the structure of the jaws and intestines, it is a most remarkable fact that the fresh waters of the Southern Hemisphere are inhabited by two genera with adipose fins so extremely similar in outward appearance to the northern Salmonoids."*

In ignorance of Dr. Günther's researches, I had previously † described the upokororo from specimens obtained in the Hutt River in January, 1870, and made the mistake of placing it in the only genus of salmonoid fishes then known to occur in New Zealand, and which is not found elsewhere (*Retropinna*).

With reference to the Australian congener of the upokororo, Professor McCoy remarks, "The Yarra Yarra and some other of the rivers near the southern coast contain in great abundance a beautiful and active fish, excellent for the table, and affording capital sport to the angler. By ichthyologists following the classification of Cuvier it would be referred to the *Salmonidæ*, the adipose second dorsal fin being well marked, and so much does it resemble the grayling in the cucumber smell when caught, in general appearance, habits, mode of rising to fly, and playing, as well as in flavour, that anglers are now in the habit of calling it 'the Australian grayling.' Its close resemblance in food and habits to the true *Salmonidæ* helped the acclimatisation society to argue that certain of our rivers would serve for the experiment

* "Proceedings Zoological Society," London, 10th March, 1870.

† Trans. N.Z. Inst., vol. iii., p. 136; Ann. Nat. Hist. 1867 (*Neochanna*).

of acclimatising the European salmon and trout, and, as experience has since shown, successfully. It is vulgarly also called the 'Yarra herring,' and is the *Prototroctes murœna*."

This description applies to the New Zealand upokororo, except that it does not possess the "cucumber smell," which, however, is as strongly marked in our other and proper native Salmonoid (*Retropinna*) as it is in the English smelt (*Osmerus eperlanus*). The upokororo appears to inhabit clear running streams in all parts of the colony, and I believe that the large fish locally called "trout," which were sometimes cast up on the beaches of the great inland lakes of Otago in the early days before trout were introduced, also belong to this species.

From all accounts they probably reached 6 lb. or 8 lb. in weight, but the usual size of this fish is under 1 lb. weight, and from 10 in. to 12 in. in length; and I have seen no specimens less than 7 in., and certainly none in the semi-larval stage of whitebait.

At certain seasons they assemble in the streams in immense shoals, and the fact of their being often seen near the mouths of rivers has given rise to the idea that the upokororo is a sea-going fish that enters the fresh water for the purpose of spawning. In my former account of this fish I adopted this view, and quoted a statement to the same effect by Mr. W. T. L. Travers, F.L.S.; but further inquiry leads me to think that these fish are constantly resident in the fresh water, and that their annual migration does not extend beyond the commencement of the brackish water.

The fishermen on the rivers of the West Coast who supply the large townships with fish obtained chiefly in the salt and brackish water within the river bars appear to be very confident that the "grayling," as they term it, does not enter the salt water; and on the same subject I have the following note from Mr. C. Hursthouse, of Taranaki: "The upokororo, which you describe as a sea-visiting fish, is not such here. I made its esteemed acquaintance years ago in our little *belle rivière* Waiwaikaiho. Natives, however, told us that it is solely an inhabitant of fresh water, that it spawns high up in the streams, and that, though always present in the pools along their courses, they come down in great numbers during floods. The only one ever found here in salt water was a dead one picked up at the mouth of the Henui after a heavy spate. Our most skilful brother of the rod, Mr. J. H. Smith, who, as shown by his diary, caught last year 1,152 of these fish in fifty-eight fishing-days, taking in one day ninety-three, thinks that upokororo would no more voluntarily get into salt water than into hot water. Here, with our rude tackle, they do not rise at the artificial fly, but

greedily bite at the small red worm, which is only found under dry stock droppings; the common garden worm has never tempted one."

As it is very probable that by many observers the large-sized smelt (*Retropinna*), which we shall find is a fish common to both fresh and salt water, is frequently mistaken for the upokororo (perhaps in Australia as well as this colony), the question is one that still requires further investigation; and it will be a most interesting fact, if it can be established, that this fish, which is so universally distributed in New Zealand, and has close allies in South America and Australia, cannot survive in sea-water. Mr. Travers observed this fish in the Maitai River in the early part of October, and I have specimens from the Hutt River, full of spawn, obtained in the month of January; while on the West Coast they are said to be caught several months later in the season, and even in winter.

The upokororo is readily distinguished from the smelt (which is the only other fish in our streams with a fleshy second dorsal lobe) by its small tumid mouth, shorter lower jaws, and minute teeth closely placed together like a comb round the jaws. They vary very much in richness of colour, from a general silvery hue and brownish on the back, while others are dark speckled brown on back, and rich yellow, almost golden in tint, on the belly.

The Smelt.

This delicate little fish, which belongs to the true *Salmonidæ*, was first described by Sir John Richardson from specimens which were obtained at the Bay of Islands with a net, and therefore, I infer, in the salt water; but it is, at certain seasons, one of the most common of our fresh-water fishes. In my former paper on the New Zealand Salmonoids* I distinguished two species of the smelt, the inanga and the proper smelt, which have been again united by Captain Hutton under the original species, *Retropinna richardsoni*. I am still, however, inclined to maintain that *R. osmeroides* should be recognised as a distinct form until more definite proof can be adduced that it is merely a different stage in the growth of the first-described species.

My first acquaintance with these fish was in 1863, at the mouth of the Kotuku River, on the west coast of Otago, where, in the month of September, both kinds were obtained, the larger variety (*R. osmeroides*) following the flood tide in numerous shoals into all the little streams to which the brackish water penetrated, leaping out of the water in a very

* Trans. N.Z. Inst., vol. iii., p. 133, pl. xviii., xix.

lively fashion—the Maoris catching them as the tide fell by closing weirs made of flax net across the small creeks. Their length was from 4 in. to 7 in., and they took bait voraciously.

The smaller fish (*R. richardsoni*), averaging 3 in. to 4 in. in length, on the other hand, chiefly appeared round the sides of the vessel in swarms at ebb tide, when the water was quite fresh, and were caught with bag nets.

Later in the season, during the month of November, the same fish was found in quantities in the Kakapo Lake, where the water is always quite fresh; but along with the smaller ones were many of larger size, averaging 4 in. in length, and having the appearance of adult fish, without showing any of their characters.

In the Blackwater, which is a tributary of the Buller River, twenty miles from the sea, a fish which answers to *R. osmeroides* is abundant from February till June, and is caught in large quantities with a net at nightfall; but the smaller fish, which was described by me as the whitebait, with a silver line on the sides, arrives in October in closely packed shoals, that advance steadily up stream against the rapids.

Captain Hutton states that in the Waikato these fish go down to the sea to spawn in April, and that the young fish return again in October; but among the specimens he collected both forms can be distinguished, although some specimens of each are of equal size.

In a collection of fishes obtained from Taupo Lake I also find a small-sized form of the smelt, which, though differing in some respects from those found in the Waikato, has decidedly the character of *R. osmeroides*.

Specimens caught sixteen miles up the Wanganui River in the month of November also have the character of *R. osmeroides*. They are 5 in. in length, and full of roe.

In the collections exhibited, which comprise all the specimens in the Museum, it is always easy to distinguish the fish which answers to Richardson's very minute description. They are of all sizes up to 4 in., at which size I consider they are adult, having a rather deep-shaped body, yellow colour with a silver streak on the side, a short conical snout, and very large eye. In the largest specimens the length of the body is less than four times that of the head, and less than five times the height of the body. The cleft of the mouth is small, and the teeth are very minute. The form of the stomach corresponds with Richardson's description, being like a fleshy tube, with a bend dividing it into an œsophageal and pyloric branch.

On the other hand, the specimens of *R. osmeroides* have the external appearance of a true English smelt, the body being

more elongated than the former species, especially in the case of the specimens from Taupo Lake. The colour (in spirits) of the Taupo specimens is also different from the others, being a brown-grey, with the silver band on the side very indistinct, whilst the other specimens are yellow. In other respects they have the same distinguishing characters from the type of *R. richardsoni*, which are an elongated snout, deeply cleft mouth, powerful jaws, and strong teeth. The stomach is also different in form, being a blind sac with the œsophageal and pyloric orifices close together.

As these differences are of considerable importance, I think it will be of advantage for observers, in recording the habits of these fish, in the meantime to distinguish between the two forms, even if they should ultimately prove to be the same species. Both the large and the small smelts form delicious food, the smallest size, when about 2 in. in length, being one of several young fish that are called "whitebait"; the large specimens, 7 in. in length, were called "aua" by the natives, which is also one name for the small sea-mullet.

Kokopu (*Genus* Galaxias).

This is the general Maori name for several very common fishes in the New Zealand streams and lakes, belonging to a family concerning which Dr. Günther makes the following very interesting remarks: "The family of *Galaxidæ* was formed by the late Johannes Müller for a single genus, *Galaxias* — scaleless freshwater fishes from the temperate zone of the Southern Hemisphere, which, with regard to the development and position of their fins, remind us of the pikes of the Northern Hemisphere, but in other respects resemble the Salmonoids, to which they have been compared by Müller. Also, the settlers in at least some parts of New Zealand have dignified the larger kinds with the name of 'trout,' or 'rock-trout.' However, they cannot be regarded as the southern representatives of the Salmonoids, inasmuch as recent researches have shown that this latter family is represented in the Southern Hemisphere by other much more closely allied genera (*Haplochiton* and *Prototroctes*). If we look for the representatives of the *Galaxidæ* in other zones, perhaps the African *Mormyridæ* and the arctic *Esocidæ* are those which may be mentioned with the greatest propriety. Up to the present time only twelve species of *Galaxias* are known. Their geographical distribution is a point to which the greatest interest attaches. We find the genus most developed in New Zealand, where five species occur, and these are the largest of the whole group. Westward it extends to New South Wales with three and to Tasmania with

two species. Another is said to be an inhabitant of the creeks of Queensland; but this is doubtful. Eastwards the same genus is met with again in the southernmost parts of America (Falkland Islands, Patagonia, Tierra del Fuego), whence three species are known; and finally a minute form is said to occur in Chile. The occurrence of the same natural genus of freshwater fishes in Australia, New Zealand, and South America would appear to be significant enough, and must be the more so when we find that even one and the same species (*Galaxias attenuatus*) inhabits the fresh waters of countries separated at present by the South Pacific Ocean."

Two species of this fish have been figured, as they are most frequently met with, and illustrate the greatest variety of external form which the genus presents in New Zealand. The kokopu proper is a fat, sluggish fish found lurking under stones and rotten logs in all the streams in the colony, however small, where not running over a clear or stony bottom. They afford very tame sport, but are fair eating, resembling the eel in flavour.

The other species (*G. attenuatus*), which is the adult form of the true whitebait of New Zealand, it is proposed to distinguish as the New Zealand minnow. It is a little fish constantly seen in most clear running streams, with very much the same habits as the English minnow. At certain seasons the young fry swarm in incredible numbers, and form the whitebait of New Zealand, but are a very poor substitute for the little herring that is so well known at Greenwich by that name. At Taupo Lake and other places in the interior small fish, which the Maoris collectively term "inanga," but which are chiefly of the species now referred to, form the food of the natives for many months in the year, and are obtained in such abundance as to yield an ample supply both for daily use and to preserve for other seasons. These small fish are caught, where streams enter the lake, with fine-meshed nets woven of green flax. Several bushels of them are frequently caught at one time, and are immediately piled on hot stones, and covered with mats and earth for half an hour or so, in the usual manner of Maori cookery, but without the addition of any water. Thus prepared, if not for immediate use, they are firmly packed in tightly plaited baskets, and in this state will keep for months, at least sufficiently well to suit the Maori taste, which is not fastidious.

The young of any of the following freshwater fishes may be taken as whitebait, but probably at different seasons and in varying localities, viz.:—

1. *Salmonoids.*—(*a.*) Grayling (*Prototroctes*). (*b.*) Smelt (*Retropinna*).

2. *Galaxias.*—The New Zealand minnow, often wrongly named "smelt." There are probably several species, but the young fry of *G. attenuatus* is undoubtedly the most common kind of whitebait in the market. It is the little fish that is scooped up with fine-meshed nets on the turn of the tide in the Grey, Hokitika, Buller, and most of the larger rivers in New Zealand.

ART. XXXVIII.—*Notes on Fish found in the Piako River.*

By Captain G. MAIR, N.Z.C.

[*Read before the Auckland Institute, 4th August, 1902.*]

WHILE visiting Pokatunawhenua, a native settlement about three miles up the Piako River, in March last, I found a party of natives catching large quantities of different kinds of fish in what they call a *tarawa*. Some stout manuka poles are put up in the channel where the current takes a straight run. The two sets of poles are from 20 ft. to 25 ft. apart, and as soon as the tide commences to ebb a funnel-shaped net is fastened in the opening, the lower edge being pinned down to the bottom by long poles with forks on them, and the top edge of the net is fastened to a bar tied from one set of stakes to the other. If the tide be favourable, it is necessary to take the fish out every quarter of an hour, and this is done by lifting the long tapering end of the net and emptying the contents into a canoe. As soon as the ebb has ceased and the flood tide comes up the net is simply turned inside out, and so the process goes on till sufficient fish are caught to occupy all hands in cleaning and drying, then the net is lifted for several days.

Assisted by a native lad, I twice lifted the net in about three-quarters of an hour, with the following result: 581 eels, from 1 ft. to 4 ft. in length, the largest the size of one's arm; eight dozen flounders, of various sizes; large numbers of aua or kataha (*Agonostoma forsteri*); about 60 lb. or 70 lb. weight of pilchard or mohimohi (*Clupea sagax*), two varieties; a few snapper, mullet, and kahawai; and hundreds of young red-cod, rarii (*Lotella bacchus*), and what I believe are the young rock-cod, or kokopu or rawaru (*Percis colias*). The red-cod were from 3 in. to 4 in. in length, and the rawaru, or, as the natives here call them, "toitoi" or "panepane," from 2 in. to 6 in. long. Very large quantities of a kind of whitebait were also caught at the same time.

The Piako River is here about 60 yards wide, and one can form some idea of the quantity of fish going up and down when such a number and variety can be taken out of a bit of water only 5 yards wide. At high tide the water is almost salt, but only slightly brackish when low.

I have never heard of either the young of the rock or red cod coming from fresh water before. There is absolute certainty about the specimens caught being the young of the red-cod (named "rarii" by the natives). In the one I am sending you will notice the two feelers hanging from the throat.

I also send some of what I suppose are pilchard; one is very much deeper in the body. What I take to be rock-cod were all too large to be put in the bottle.

III.—BOTANY.

ART. XXXIX.—*On the Pollination of* Rhabdothamnus solandri, *A. Cunn.*

By D. PETRIE, M.A.

[*Read before the Auckland Institute, 7th July, 1902.*]

RHABDOTHAMNUS, a genus of the *Gesneriaceæ*, is the only New Zealand representative of this extensive order of tropical and subtropical plants, and *R. solandri*, A. Cunn., is its only species. The Maori name is "kaikaiatua."

The plant is known to range throughout the North Island, and is fairly plentiful on the edges of the more open forests of this district. It is a slender much-branched shrub, of compact habit, and 6 ft. to 8 ft. in height. In the vicinity of Warkworth and of Whangarei it is plentiful, in both of which districts I had opportunities of studying it last November.

The flowers grow singly or in pairs in the axils of the leaves, and are produced in considerable numbers, appearing in a constant succession throughout the summer. They are borne on short slender peduncles, and stand out from the twigs sometimes in a horizontal but usually in a slightly drooping position. The corolla, which is pale-orange with red stripes, and from $\frac{1}{2}$ in. to $\frac{2}{3}$ in. in length, is distinctly conspicuous. It is irregular in form, being two-lipped, the upper lip shortly two-lobed and the lower more deeply three-lobed. The external surface is more or less pubescent-pilose, but the inside of the cup is perfectly smooth.

The stamens, four in number, are inserted near the bottom of the corolla-tube. A fifth imperfect filament is sometimes present.

The two upper filaments are nearly straight, and lie directly along the upper part of the corolla-tube, while the two lower sweep downwards and outwards in a bow-like curve along the lower interior surface of the tube, bending sharply at their ends so as to nearly meet the apices of the upper pair.

The anthers cohere, even in the unopened flower, into a cruciform or somewhat horse-shoe-shaped disc. When the flower opens the anther disc lies at the mouth of the corolla, almost touching the upper border of its tube, and is so placed that the front of the pollen-sacs faces the axis of the flower. The back of the disc, formed from the confluent connectives, is smooth and polished. As soon as the flower

opens the pollen-sacs dehisce, and the fine pollen-grains, which are very numerous, are freely exposed. At this stage in the development of the flower the slender style is hardly half the length of the corolla, and ends in a blunt point.

In the course of a few days the filaments lose their rigidity and gradually shrivel. As the shrivelling proceeds the anther disc is moved across the centre of the flower, and finally rests against the middle lobe of the lower lip of the corolla. Here it remains, more or less closely appressed to the tube and retaining the spare pollen between the disc and the inner wall of the corolla. While this movement of the anther disc is in progress the style elongates, keeping close to the uppermost part of the corolla-tube. The top then bends sharply towards the axis of the flower, and expands into a rather broad rounded finely papillose stigmatic surface. When ready for pollination the style is as long as the corolla-tube, and the stigma stands a little above the centre of the flower. By this time the anther disc is appressed to the lower lip. While these changes are in progress the bottom of the corolla-tube is provided with a store of nectar that is secreted copiously and almost continuously.

Such being the structure of the flower and the order of development of its various parts, it is evident that under normal conditions it cannot be self-fertilised. The pollen is ripe and exposed long before the stigma begins to form, and the downward movement of the anther disc before the stigma is mature effectually removes the remaining pollen-grains from the neighbourhood of the ripe stigma. The process of pollination thus combines proterandry with an additional safeguard against self-fertilisation in the form of a movement withdrawing the anther disc from the neighbourhood of the spot which the mature stigma will occupy. I am not acquainted with such a combination as this in the pollination of any other native plant.

The means by which pollination is effected is at present uncertain. Though on two occasions I spent several hours of bright weather in watching for insect visitors to the flowers, I did not see an insect visit a single flower. It may be that they are visited by moths in the dusk and are thus fertilised, but the absence of scent makes this unlikely.

The fact that many of the older flowers have their corollas ruptured towards the base of the tube points rather to small birds as the agents in effecting pollination. The corolla, which is as wide as a thimble, would readily admit the beak and part of the head of a small bird. The colouring of the flower, too, is in keeping with this view, for flowers fertilised by birds are said to be usually orange and often striped with red.

I am not aware that we have in New Zealand moths large enough to rupture a corolla so large as that of *Rhabdothamnus*, for the flower is torn for fully two-thirds of its length, and not simply pricked or bitten through.

From what has been said we can easily suppose how this nicely adjusted mechanism works. Bird visitors to the newly opened flowers will have the forehead dusted with pollen from the ripe anther disc. On visiting flowers that have been open several days this pollen will come in contact with the large papillose stigma, which now occupies the position the anther disc occupied before, and thus pollination is effected.

It is likely that pollen from the same plant will be applied to a ripe stigma as often as that from another plant, for on the same shrub flowers in all stages of development may generally be found. The shrubs, however, are usually gregarious, so that true cross-pollination must often ensue. Whether pollen from a different plant is prepotent over that from other flowers on the same plant is a point that can be settled only by a series of experiments.

One or two further details are of interest. The covering of stiffish pubescent hairs that overspreads the outer surface of the corolla-tube doubtless serves to ward off small insects, such as ants, that might steal the nectar without in any way contributing to pollination.

The position of the flowers is such as would best suit the approach of small birds hovering on the wing while extracting the nectar. The twigs are so fine that they would hardly afford foothold for even the smallest native birds, or even support their weight. The rupturing of the flowers is no doubt an accidental phenomenon, caused by the bird's body falling below the level of the axis of the flower. It is certain that many flowers set seed that are never ruptured.

Art. XL.—*On the* Musci *of the Calcareous Districts of New Zealand, with Descriptions of New Species.*

By Robert Brown.

[Read before the Philosophical Institute of Canterbury, 1st August, 1902.]

Plates XXXV.–XL.

The following contribution towards a better knowledge of the bryology of New Zealand consists of descriptions of species collected in various places in New Zealand since the genera to which the species belong were treated of by me in papers previously read before this Institute. The greater number of the species described in this paper were collected from cal-

careous rocks, or on the *débris* of these—*e.g.*, Castle Hill, Weka Pass, Kaikoura, and at Weston, near Oamaru. These districts, like calcareous districts in other countries, possess a special flora of their own which is strictly confined to these rocks, and thus far has not been found growing in any other habitats.

Grimmia (Schistidium) argentea,* described in a former paper read before this Institute, has only been found on the rocks at Castle Hill, and is very rare in that habitat.

Seligeria cardotii,† also described in a former paper, was first found at Castle Hill, and since then it has been collected at the Weka Pass and near Oamaru. *Bryum oamaruense*,‡ from the last-named district, is another rare moss, being confined to one piece of rock from 3 ft. to 4 ft. in diameter, and although I botanised all over the district for eight days I found it in no other habitat. In the interests of botany I left specimens of it sufficient to replenish the rock on which it grows.

Gymnostomum brotherusii, described in this paper, is another of these rare plants, being confined to a small abandoned quarry on Mr. Allen's property, about 20 yards wide, from which stone had been taken to form the road which passes near it. There are also several new species from the Oamaru district, which are rare, described in this paper.

Gymnostomum gibsonii, also described in this paper, has only been collected in the Kaikoura district; it is plentiful, and grows in strips along the bases of precipitous rocks in the South Bay, and, although common, is seldom found in fruit owing to the dryness of the habitats. There are also several other rare species from this neighbourhood described in this paper which have not been found thus far in any other locality.

From a geological point of view the rocks on which these plants grow are extremely interesting from the large number of fossils which they contain, but from a botanical one they present an arid uninteresting appearance, which has hitherto prevented a thorough examination of them being made to ascertain the number and positions of the plants that exist there. Only the larger ones have hitherto been collected, although in the crevices and out-of-the-way nooks and places there are to be found some of the smallest and rarest species of *Musci* in New Zealand. They are of much interest, some of them for their rarity, others for their extreme smallness, and all of them for the arid and adverse conditions under which they continue to exist.

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* R. B., in Trans. N.Z. Inst., 1894, vol. xxvii., p. 412.

† R. B., in Trans. N.Z. Inst., 1894, vol. xxvii., p. 423.

‡ R. B., in Trans. N.Z. Inst., 1898, vol. xxxi., p. 447.

In November, 1889, while botanising at Castle Hill, my attention was attracted by a small round white object about $\frac{1}{8}$ in. in size. It was attached to a dry perpendicular rock exposed to the full glare of the sun. Thinking it was the nest of some small insect, I examined it with a pocket-lens, and was surprised to find it was a very small moss, with the leaves curled over an immersed capsule. This was the manner in which *G. argentea* was discovered. The whole plant was only $\frac{1}{8}$ in., with an unbranched stem and an immersed capsule.

Grimmia diminutum is also from the above-named rocks, being only $\frac{1}{32}$ in. One capsule of this moss is all that has been discovered. This district is a large one, and has not yet been fully examined, so that what exists in it has not been ascertained.

At Weston, near Oamaru, the calcareous rocks are most extensive, extending for miles in irregular masses, with high precipitous cliffs fronting in a south-western direction. From the base of these cliffs descends a steep bank, in several places some hundreds of feet high, as at Cormack's Siding, on the railway. Near this point the well-known non-calcareous diatomaceous ooze has been exposed in the railway-cutting; its depth is not known. Above this stratum and about halfway below the cliffs there is another stratum of diatomaceous ooze which is calcareous, and extends all along the district at about the same level. In several places the adjoining fields are nearly on a level with this stratum, and the plough has gone over it; but the line of the deposit was clearly seen all along these fields by the darker colour of the earth and pieces of it which had not mouldered into fine dust. On the steep portions of the bank, although generally covered with grass, it could be easily traced, being damp, slippery, and in places as plastic as clay. This bed had been opened in several places and a quantity of it taken away, and at these places it was dry. This stratum is from 20 ft. to 30 ft. in thickness, and it was near, or on the line of, this deposit that most of the mosses collected in this district were found. They were either on calcareous rocks which had fallen from the cliffs above, or on *débris* near them. To those who take an interest in this subject the above imperfect description will enable them to find the most interesting of the habitats in this district.

In the beginning of January, 1898, having arrived at Kaikoura on a botanical exploring expedition, and being anxious to collect on the high hill adjoining Mount Fyfe (on the summit of which snow still remained), and as I was unable in Kaikoura to obtain any information regarding the name of the hill or how to get on to it, I rose one morning early, and, after reconnoitring it at a distance, walked

straight towards an opening between Mount Fyfe and the hill I wished to get on. Through this opening the River Hapuka emerges from the hills, the distance from Kaikoura being between seven and eight miles. Having arrived at this point early in the day, I was in hopes of being able to botanise on the hill for several hours, and also to reach the summit; but after travelling up the rough bed of the river for about a mile the banks approached close to the water's edge, and further progress up the stream was barred by high perpendicular rocks on both sides and a foaming torrent in front. Subsequently I tried to reach the hill by going up the creeks tributary to the Hapuka, but without success, as I found that none of them led anywhere near it. After having made the above attempt I was informed that the north branch of the Hapuka led to one of the northern spurs of the hill. The spur appeared a great distance away, and I did not attempt to reach it, but confined my operations to examining the vegetation on the river-banks until I arrived above a narrow gorge in the limestone rocks abraded by the water of the river. My reason for not attempting to get to the hill by this way was because I had on the previous day discovered a route about 200 yards below the torrent above mentioned. By climbing up the steep bank of the river the bush was reached, which led up to the open hill above the bush-line. When the limit of the bush was reached a thunder-storm came on, accompanied by heavy rain, which put an end to further research in that direction.

All the mosses recorded by me from the neighbourhood of Kaikoura in this and previous papers, with the exception of two, were collected in the district drained by the River Hapuka and its tributaries.

On several days during the time I remained in Kaikoura I botanised on the coast-line, an agreeable change from travelling on boulders in the river-beds. The line of coast from the south of the Mokonui River to within a few miles of the mouth of the Clarence River was examined, and in the sandy bed of the Mokonui, growing in the mud, was found the moss recorded in this paper as *Trichostomum mokonuiense*. It was rather scarce, and this so far is its only known habitat. The country from this river to near Kaikoura is flat and uninteresting, and at the season of the year I visited it was completely dried up. Near Kaikoura are numerous precipitous cliffs, and along their bases grows the moss named *Gymnostomum gibsonii*. It is very common, but is rarely found in fruit. These two mosses were the only new ones collected on a line of upwards of twenty miles.

Genus **Gymnostomum**.

1. *G. salmonii*, sp. nov. Plate XXXV., fig. 1.

Plants monœcious, perennial, growing in gregarious patches. *Stems* $\frac{1}{32}$ in., branching from the base. *Leaves* few and small, erecto-patent, ligulate, rounded at the apex, obtuse or acute; margins entire; nerve ending below the apex. *Areola* small. *Perichætial leaves* longer than the stem ones and broader at the base, clasping the fruitstalk; nerve ending below the apex. *Fruit* acrocarpous. *Fruitstalk* slender, yellow, inclined, $\frac{5}{16}$ in. long. *Capsule* yellowish, ovate, very small, with a reddish ring round the mouth. *Operculum* nearly as long as the capsule, conico-rostrate, oblique, stoutish. *Peristome* none. *Calyptra* small, cucullate.

Hab. On damp limestone rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

This moss is very rare and local, and so small that the rock had to be cut with a knife to obtain the plants entire. So far this is the only habitat known. Named after Ernest S. Salmon, Kew House, Kew.

2. *G. brotherusii*, sp. nov. Plate XXXV., fig. 2.

Plants monœcious, perennial, growing in large dense tufts as much as 7 in. diameter, reddish-brown. *Stem* $1\frac{1}{4}$ in. long, matted with radicles, branches fastigiate. *Leaves* imbricating, small, erecto-patent, ligulate, obtuse or rounded at the apex; margins entire; nerve ending below the apex. *Areola:* Upper small, roundish; lower oblong; nearly erect when dry. *Perichætial leaves* smaller than the stem ones, innermost smallest, clasping the fruitstalk; nerve ending below the apex. *Fruit* acrocarpous. *Fruitstalk* red, inclined, about $\frac{1}{4}$ in. long. *Capsule* inclined, ovate. *Operculum* stout, oblique, conico-rostrate, two-thirds the length of the capsule. *Peristome* none. *Calyptra* cucullate.

Hab. On wet rocks in a small abandoned quarry at Weston, near Oamaru. Collected by Robert Brown, November, 1897.

Plants rare, being confined to the above-named habitat.

Named after Dr. Brotherus, of Helsingfors.

3. *G. gibsonii*, sp. nov. Plate XXXV., fig. 3.

Plants monœcious, perennial, growing in dense patches about 1 in. high, bright-green above, brown below. *Branches* dense, fastigiate. *Leaves* small, closely imbricating, erecto-patent or slightly recurving, linear-lanceolate, acute or acuminate; margins entire; nerve ending slightly below the apex. *Areola:* Upper small, roundish; lower larger, oblong; leaves erect when dry. *Perichætial leaves* very similar to

the stem ones; nerve ending below the apex. *Fruit* acrocarpous. *Fruitstalk* inclined, slender, pale, $\frac{5}{16}$ in. long. *Capsule* short, ovate-oblong, narrowing towards the base. *Peristome* none. *Operculum* and *calyptra* not found.

Hab. At the base of calcareous cliffs, South Bay, Kaikoura. Common in this situation, but rarely fruiting; only known habitat. Collected by Robert Brown, January, 1898.

Named after Walter Gibson, Esq., Kaikoura.

4. *G. parisii*, sp. nov. Plate XXXV., fig. 4.

Plants monœcious, perennial, growing in dense patches, green, $\frac{1}{8}$ in. high. *Branches* fastigiate. *Leaves* small, closely imbricating, ovate-subulate, tapering to an acute point or obtuse, and the nerve ending below the apex; margins entire; nerve disappearing in the acute leaves at the apex. *Areola:* Upper small, roundish; lower oblong; leaves erect when dry. *Perichætial leaves* erect, ovate-lanceolate, acuminate; nerve ending below the apex. *Fruit* acrocarpous. *Fruitstalk* inclined, reddish, $\frac{3}{16}$ in. long. *Capsule* small, ovate-oblong or ovate. *Operculum* conico-rostrate, about one-half the length of the capsule. *Peristome* none. *Calyptra* cucullate.

Hab. On limestone *débris* at the head of one of the tributaries of the River Hapuka, north of Kaikoura. Collected by Robert Brown, January, 1898.

Named after General Paris, editor of the *Revue Bryologique*.

5. *G. westlandicum*, sp. nov. Plate XXXV., fig. 5.

Plants monœcious, perennial, growing in small patches, dark-green, $\frac{1}{4}$ in. high. *Stem* $\frac{1}{8}$ in. *Branches* dense, $\frac{1}{8}$ in., fastigiate. *Leaves* closely imbricating, erecto-patent, linear or linear-lanceolate, acuminate, slightly recurving; margins entire; nerve continued to the apex. *Areola:* Upper small, dense; lower quadrilateral; leaves crisp when dry. *Perichætial leaves* erect, shorter than the stem ones and narrower, sheathing the fruitstalk, inner smallest. *Fruit* acrocarpous. *Fruitstalk* inclined, $\frac{1}{8}$ in. long, pale. *Capsule* cylindric. *Operculum* conico-rostrate, half the length of the capsule. *Peristome* none. *Calyptra* not found.

Hab. On damp banks, west coast of the South Island. Collected by Robert Brown, January, 1902.

Genus **Weissia.**

6. *W. kaikouraensis*, sp. nov. Plate XXXV., fig. 6.

Plants monœcious, perennial, growing in small patches about $\frac{1}{4}$ in. high. *Branches* very short, fastigiate. *Leaves* closely imbricating, erecto-patent, subulate, base slightly broader, convolute in the upper half; margins minutely

papillose; nerve disappearing below the apex. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* slightly smaller than the stem ones, otherwise similar. *Fruit* acrocarpous. *Fruitstalk* inclined, $\frac{5}{16}$ in. long. *Capsule* ovate or shortly ovate-oblong. *Operculum* oblique, conico-rostrate, as long as the capsule. *Peristome* single; teeth 16, in pairs. *Calyptra* not found.

Hab. North branch of the Hapuka. Collected by R. Brown.

7. *W. (?) searellii*, sp. nov. Plate XXXVI., fig. 7.

Plants monœcious, perennial, growing in very dense patches, reddish-brown above, congested below, with radicles about 1 in. high. *Branches* $\frac{1}{8}$ in. long, fastigiate. *Leaves* small, imbricating, erecto-patent, linear or linear-lanceolate, rounded at the apex; margins entire, keeled; nerve ending below or at the apex. *Areola:* Upper small, oval; lower small, quadrilateral; leaves erect when dry. *Perichætial leaves* erect, shorter than the stem ones, otherwise similar. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{4}$ in. long, red, twisted slightly when dry. *Capsule* small, ovate-oblong. *Peristome* single, red, incomplete. *Operculum* and *calyptra* not found.

Hab. On rocks, Jollie's Pass. Collected by Trist Searell.

Genus **Pottia.**

8. *P. whittonii*, sp. nov. Plate XXXVI., fig. 8.

Plants monœcious, annual, growing in small patches, gregarious, $\frac{1}{18}$ in. high, dark-green. *Leaves* imbricating, spreading or erecto-patent, small, oblong-apiculate, apex slightly incurved; margins entire; nerve excurrent. *Areola:* Upper large, roundish; lower quadrilateral; leaves twisted when dry. *Perichætial leaves* slightly smaller than the stem ones, but otherwise similar. *Fruit* acrocarpous. *Fruitstalk* pale, $\frac{1}{8}$ in. long, inclined. *Capsule* small, ovate. *Operculum* conico-rostrate, slightly oblique, about half the length of the capsule. *Calyptra* not found.

Hab. On damp banks near Weston, close to Oamaru, November, 1897. Collected by R. Brown.

Genus **Dicranum.**

9. *D. cardotii*, sp. nov. Plate XXXVI., fig. 9.

Plants diœcious, perennial, growing in small patches, yellowish-green, $\frac{3}{8}$ in. high. *Branches* subfastigiate. *Leaves* imbricating, small, erecto-patent or spreading, flexuous, subulate from a quadrate sheathing-base; nerve faint, disappearing in the subulate point; margins minutely papillose. *Areola:* Upper dense; lower oblong, without large alar cells. *Perichæ-*

tial leaves longer, erect, otherwise similar to the stem ones *Fruit* acrocarpous. *Fruitstalk* about ⅓ in. long, slender, inclined, pale-red. *Capsule* small, narrowly ovate-oblong. *Operculum* long, oblique, conico-rostrate; beak long, slender, about a third longer than the capsule. *Calyptra* cucullate. *Male inflorescence* gemmiform on separate plants.

Hab. On damp banks, tributary of the River Hapuka, near Kaikoura. Collected by Robert Brown.

10. *D. waimakaririense*, sp. nov. Plate XXXVI., fig. 10.

Plants monœcious, perennial, growing in loose patches, pale yellowish-green, ¼ in.–½ in. high. *Branches* few. *Leaves* imbricating, erecto-patent or spreading, secund, ovate-subulate, lower half erect, sheathing the stem; margins entire; nerve disappearing in the subulate apex. *Areola:* Lower quadrilateral. *Perichætial leaves* smaller, otherwise similar to the stem ones. *Fruit* acrocarpous. *Fruitstalk* inclined slightly, flexuous, red. *Capsule* inclined, ovate. *Operculum* stout, oblique, conico-rostrate, nearly as long as the capsule. *Peristome* single; teeth 16, lanceolate, bifid to near the middle, red. *Calyptra* small, cucullate.

Hab. On wet mud on the bed of the River Waimakariri. Collected by Robert Brown, August, 1899.

11. *D. kowaiense*, sp. nov. Plate XXXVI., fig. 11.

Plants monœcious, perennial, growing in dense dark-green patches ⅛ in.–¼ in. high. *Branches* short, fastigiate, ⅛ in. *Leaves* imbricating, erecto-patent or recurving from the middle to the apex, linear, rounded or obtuse; margins entire; nerve ending below the apex. *Areola:* Upper small, round; lower quadrilateral. *Perichætial leaves* slightly smaller, innermost smallest, linear, obtuse. *Fruit* acrocarpous. *Fruitstalk* ¼ in. long. *Capsule* small, ovate-oblong. *Operculum* oblique, conico-rostrate, about half the length of the capsule. *Peristome* single, irregular; teeth 16, bifid or perforated on the middle line. *Calyptra* cucullate.

Hab. On wet precipitous rocks in the gorge of the River Waimakariri, growing in company with *D. tasmanicum*, which it approaches in all its characters except size. Collected by Robert Brown, January, 1900.

Genus **Trichostomum.**

12. *T. stanilandsii*, sp. nov. Plate XXXVI., fig. 12.

Plants monœcious, gregarious, yellowish-green, ¼ in.–½ in. high, nearly simple. *Leaves* imbricating, secund, falcate, lower half ovate-lanceolate, upper half subulate, subcucullate at the apex; margins entire; nerve disappearing towards the apex. *Areola:* Upper small, dense; lower quadrilateral;

leaves erect when dry. *Perichætial leaves* slightly longer; lower half erect, sheathing, oblong; upper subulate, secund, falcate. *Fruit* acrocarpous. *Fruitstalk* inclined, slender, red, $\frac{3}{8}$ in. long. *Capsule* cylindric, curved. *Operculum* conic, one-fifth the length of the capsule. *Peristome* single, fragile; teeth 16, linear. *Calyptra* cucullate.

Hab. On damp banks near Lake Kanieri, and on banks by the roadside near Hokitika. Collected by Robert Brown, January, 1902.

13. *T. kanieriense*, sp. nov. Plate XXXVII., fig. 13.

Plants perennial, monœcious, growing in small gregarious tufts about $\frac{1}{2}$ in. high, pale yellowish-green. *Branches* few, short. *Leaves* imbricating, erecto-patent, ridged when moist, erect and incurved at the apex when dry, ovate or oblong-lanceolate, tapering to an obtuse point; margins entire; nerve continued to apex. *Areola:* Upper subrotund; lower linear-oblong. *Perichætial leaves* longer than the stem ones, convolute, sheathing, the fruitstalk tapering to an obtuse point. *Fruit* acrocarpous. *Fruitstalk* inclined, $\frac{5}{8}$ in. long, brown. *Capsule* long, cylindric, curved slightly. *Operculum* conico-subulate, one-seventh the length of the capsule. *Peristome* single; only a few broken teeth were found.

Hab. On damp banks near Lake Kanieri, West Coast. Collected by R. Brown, January, 1902.

14. *T. whittonii*, sp. nov. Plate XXXVII., fig. 14.

Plants perennial, growing in small patches about $\frac{1}{4}$ in. high, glaucous-green. *Branches* fastigiate. *Leaves* erecto-patent, slightly spreading, flexuous or recurving, linear-subulate, subconvolute, minutely toothed at the apex; nerve disappearing in the upper portion of the leaf. *Areola:* Upper small, quadrate; lower quadrilateral; leaves scarcely altered when dry. *Perichætial leaves* similar to the stem ones. *Fruit* acrocarpous. *Fruitstalk* slender, red, $\frac{1}{4}$ in. long. *Capsule* cylindric. *Peristome* imperfect. *Operculum* and *calyptra* not found.

Hab. On damp banks, Staircase Gully, Mount Torlesse. Collected by R. Brown, January, 1900.

15. *T. theriotii*, sp. nov. Plate XXXVII., fig. 15.

Plants monœcious, perennial, growing in tufts, yellowish-green, $\frac{1}{8}$ in.–$\frac{1}{2}$ in. high, branched from near the base, fastigiate. *Leaves* erecto-patent or slightly spreading, imbricating, very small, upper ones oblong or ovate-lanceolate, obtuse or rounded at the apex; margins entire; nerve ending below the apex. *Areola:* Upper subrotund; lower small, quadrilateral. *Perichætial leaves* smaller than the upper ones, ligulate,

innermost smallest; nerveless. *Fruit* acrocarpous. *Fruitstalk* slender, $\frac{3}{16}$ in. long, inclined, pale. *Capsule* very small, cylindric. Being overmatured, neither the operculum, peristome, nor calyptra were seen, but the moss is undoubtedly a *Trichostomum.* It had fruited freely, but insects had destroyed nearly all the capsules.

Hab. Seams of rocks near Kaikoura. It appears to be rare, as only a small portion was obtained. Collected by R. Brown, January, 1896.

Named after M. J. Theriot, Directeur de L'Ecole Primaire Superieure du Havre.

16. *T. mokonuiense*, sp. nov. Plate XXXVII., fig. 16.

Plants monœcious, small, gregarious, yellowish-green, $\frac{1}{8}$ in.–$\frac{1}{4}$ in. high. *Branches* fastigiate. *Leaves* small, erecto-patent, lanceolate- or linear-lanceolate, subacute, semi-convolute, slightly incurving at the apex; margins entire; nerve slender, continued to the apex. *Areola:* Upper small, subrotund; lower quadrilateral; leaves incurved at the apex when dry. *Perichætial leaves* erect, smaller than the upper stem ones, lanceolate, acute; margins entire; nerve continued to the apex. *Fruit* acrocarpous. *Fruitstalk* slender, $\frac{1}{4}$ in. long, reddish. *Capsule* small, cylindric. *Operculum* narrow, conico-rostrate, two-thirds the length of the capsule. *Peristome* single; teeth 16, linear. *Calyptra* cucullate.

Hab. On damp mud in the bed of the River Mokonui, near its junction with the sea. Collected by Robert Brown, January, 1898.

Genus **Orthotrichum.**

17. *O. oamaruense*, sp. nov. Plate XXXVII., fig. 17.

Plants perennial, monœcious, growing in small dense tufts $\frac{1}{4}$ in.–$\frac{1}{2}$ in. high, dark-green above, black below. *Stem* short, subdichotomously branched. *Branches* fastigiate. *Leaves* imbricating, erecto-patent, oblong-lanceolate, acute; margins recurved, occasionally plain, entire; nerve slender, keeled, disappearing at the apex. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* slightly smaller than the stem ones, erect. *Fruit* acrocarpous. *Fruitstalk* extremely short. *Capsule* narrow, elliptic, immersed in the perichætial leaves. *Operculum* stout, one-quarter the length of the capsule. *Peristome* single; teeth 8, slightly perforated near the apex. *Calyptra* small, mitriform, pilose.

Hab. On limestone rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

18. *O. oamaruanum*, sp. nov. Plate XXXVII., fig. 18.

Plants perennial, monœcious, growing in small dense tufts, brown above, dark-brown below, $\frac{3}{8}$ in.–$\frac{1}{2}$ in. high, dichoto-

mously branched, subfastigiate. *Leaves* imbricating, erecto-patent, ovate-lanceolate, acute or obtuse; margins recurved below the apex; nerve keeled, disappearing below the apex. *Areola:* Upper small, dense; lower small, quadrilateral; leaves erect and adpressed when dry. *Perichætial leaves* similar to the stem ones, but rather more subulate at the apex. *Fruit* acrocarpous. *Capsule* small, subsessile, turbinate, narrowed at the mouth. *Operculum* straight, conico-rostrate, about one-third the length of the capsule. *Peristome* single; teeth 8, scarcely cohering on the middle line, bifid to near the base, membranous. *Calyptra* mitriform, slightly pilose near the apex.

Hab. On limestone rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

19. *O. beckettii*, sp. nov. Plate XXXVIII., fig. 19.

Plants perennial, monœcious, growing in tufts, light-green above, brown below, 1½ in.–2 in. high, subdichotomously branched. *Branches* fastigiate. *Leaves* imbricating, erecto-patent or spreading, ovate-lanceolate, acute or acuminate from an erect sheathing-base; margins minutely papillose towards the apex; nerve ending at or below the apex; nearly erect when dry. *Areola:* Upper small, oval; lower linear near the base. *Perichætial leaves* smaller than the upper ones, erect, linear-lanceolate, acute. *Fruit* acrocarpous. *Fruitstalk* about $\frac{1}{16}$ in. long, erect. *Capsules* oval, from 1 to 6 together, most commonly 3; paraphyses numerous. *Operculum* not found. *Peristome* double; outer teeth 8, dense; inner 8, alternate with the outer ones, free to the base, composed of two rows of round cells. *Calyptra* small, mitriform, pilose.

Hab. On bark of trees, Otira Gorge. Collected by R. Brown, January, 1902.

20. *O. otiraense*, sp. nov. Plate XXXVIII., fig. 20.

Plants perennial, monœcious, growing in tufts ½ in. high, yellowish-green, dichotomously branched. *Branches* fastigiate. *Leaves* imbricating, erecto-patent, slightly flexuous, narrowly ovate-lanceolate, acute, concave; margins entire; nerve ending at the apex; leaves crisp when dry. *Areola:* Upper small, round; lower small, quadrate. *Perichætial leaves* nearly erect, narrowly ovate-lanceolate, acute. *Fruit* acrocarpous. *Fruitstalk* $\frac{3}{16}$ in. long, flexuous. *Capsule* exserted, ovate. *Operculum* not found. *Peristome* single, tight, imperfect. *Calyptra* small, mitriform, very pilose.

Hab. On bark of trees, Otira Gorge. Collected by R. Brown, January, 1902.

Genus **Bryum.**

21. *B. foresterii*, sp. nov. Plate XXXVIII., fig. 21.

Plants perennial, monœcious, growing in dense patches dark-green, brown below, $\frac{1}{8}$ in. high. *Branches* $\frac{1}{16}$ in., fastigiate. *Leaves* small, densely imbricating, erecto-patent, tapering from a broad base to an acuminate point or a narrow triangular acuminate outline; margins entire; nerve stout, keeled, ending at the apex or disappearing near it. *Areola:* Upper obliquely quadrilateral, becoming larger below; leaves erect when dry. *Perichætial leaves* about half smaller than the stem ones, nearly erect, deltoid, acuminate. *Fruit* acrocarpous. *Fruitstalk* inclined, about $\frac{1}{4}$ in. long, curved at the apex, dark-red. *Capsule* pendular or horizontal, narrow, pyriform. *Operculum* mammillate. *Peristome* and *calyptra* not seen.

Hab. On calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, 18th November, 1897.

Named after Mr. Forester, Harbourmaster, Oamaru.

22. *B. whittonii*, sp. nov. Plate XXXVIII., fig. 22.

Plants small, perennial, gregarious, $\frac{1}{4}$ in. high, yellowish-green. *Stem* nearly simple, fastigiate. *Leaves* imbricating, subsecund, flexuous or spreading, falcate, linear-subulate, acuminate; margins entire; nerve disappearing below the apex. *Areola:* Upper obliquely quadrilateral; lower larger; leaves scarcely altered when dry. *Perichætial leaves* smaller than the upper ones, innermost smallest. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{2}$ in. long, curved at the apex, slender, pale-red. *Capsule* horizontal, ovate, narrowing into the fruitstalk. *Operculum* conic, about one-sixth the length of the capsule. *Peristome* double; outer teeth 16, linear-lanceolate; inner, 16 cilia, alternating with the outer ones, membranous, united near the base. *Calyptra* not found.

Hab. On damp banks near Kaikoura; appears to be rare. Collected by R. Brown, January, 1898.

23. *B. barrii*, sp. nov. Plate XXXVIII., fig. 23.

Plants perennial, growing in dense patches, dark-green, $\frac{1}{2}$ in.–$\frac{3}{4}$ in. high, slender, irregularly branched. *Branches* slender. *Leaves* small, imbricating, erecto-patent or flexuous, narrow, ovate-subulate, acute; margins entire; nerve disappearing below the apex. *Areola:* Upper narrow, obliquely quadrilateral; lower larger; leaves erect when dry. *Perichætial leaves* linear-subulate; nerve ending below the apex. *Fruit* acrocarpous. *Fruitstalk* slender, pale-red, curved at the apex, $\frac{1}{2}$ in. long. *Capsule* horizontal or pendular, shortly

ovate-oblong. *Operculum* conic, one-fifth the length of the capsule. *Peristome* double; outer teeth 16, linear-lanceolate; inner membranous, 16 cilia, alternating with the outer ones, united below.

Hab. On damp banks on the west coast of the South Island. Collected by R. Brown, January, 1902.

24. *B. theriotii*, sp. nov. Plate XXXVIII., fig. 24.

Plants perennial, monœcious, growing in small tufts about ⅜ in. high. *Branches* short, fastigiate, darkish-green. *Leaves* imbricating, erecto-patent, small, short, ovate, acute or acuminate; margins entire; nerve excurrent. *Areola:* Upper narrow, obliquely quadrilateral; lower ones larger. *Perichætial leaves* smaller than the upper ones, triangular; nerved to the apex. *Fruit* acrocarpous. *Fruitstalk* inclined, ½ in. high, curved at the apex. *Capsule* large, oval. *Operculum* short, convex. *Peristome* double; outer teeth 16, lanceolate; inner 16, membranous, alternating with the outer, united below the base.

Hab. On damp rocks, head of Governor's Bay, Port Lyttelton. Collected by R. Brown, January, 1899.

Genus **Blindia,** Wils.

25. *B. theriotii*, sp. nov. Plate XXXIX., fig. 25.

Plants perennial, diœcious, growing in patches ¾ in. high, yellow-green above, pale-brown below. *Branches* fastigiate. *Leaves* closely imbricating, secund, recurving or erecto-patent, subulate from a short broad erect sheathing-base; nerve disappearing in the subulate portion; scarcely altered when dry. *Areola:* Upper linear; lower quadrilateral, with large quadrate alar cells at the basal angles. *Perichætial leaves* smaller, erect, with an oblong sheathing-base, and the upper half subulate. *Fruit* acrocarpous. *Fruitstalk* curved, about ¼ in. long. *Capsule* small, rotund; mouth narrow. *Operculum* conico-rostrate; beak subulate, straight, two-thirds the length of the capsule, which is immersed among the leaves when moist, erect when dry. *Peristome* single; teeth 16, lanceolate, sometimes perforated, upper two-thirds membranous. *Calyptra* cucullate.

Hab. On wet rocks or banks, Staircase Gully and Cascade Creek, Mount Torlesse. Collected by R. Brown, January, 1900.

26. *B. (?) torlessensis*, sp. nov. Plate XXXIX., fig. 26.

Plants perennial, growing in small dense tufts about ¼ in. high, yellowish-brown, branching irregularly, subfastigiate. *Leaves* loosely imbricating, erecto-patent, subulate from a short

ovate erect sheathing-base, subulate portion twice the length of the base; margins entire; nerve disappearing in the subulate point. *Areola:* Upper quadrate; lower quadrilateral; leaves erect when dry. *Perichætial leaves* slightly longer than upper ones, but otherwise similar to them. *Fruit* acrocarpous. *Fruitstalk* inclined, $\frac{5}{16}$ in. long, red. *Capsule* subturbinate; mouth wide. *Peristome* single; teeth 16, red, bifid for one-third of their length. *Operculum* stout, oblique, conico-rostrate about half the length of the capsule. *Calyptra* not found.

Hab. Damp banks, Mount Torlesse. Collected by R. Brown, December, 1896.

Genus **Grimmia**.

27. *G. (Schistidium) oamaruense,* sp. nov. Plate XXXIX., fig. 27.

Plants monœcious, perennial, growing in small patches $\frac{3}{16}$ in. high, brownish, branched from the base. *Branches* fastigiate. *Leaves* closely imbricating, erecto-patent, oblong-lanceolate, acute, with a minute hyaline tip; margins recurved or plain; nerve continued to the apex, keeled; leaves erect when dry. *Areola* small, roundish to the base. *Perichætial leaves* smaller than the upper ones, innermost smallest, oblong-lanceolate, acute. *Fruit* acrocarpous. *Fruitstalk* extremely short. *Capsule* turbinate, small, immersed in the perichætial leaves. *Operculum* mammillate or convex-apiculate. *Peristome* 16, lanceolate, tapering to a slender point, red, entire or perforated.

Hab. On damp calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

28. *G. turnerii,* sp. nov. Plate XXXIX., fig. 28.

Plants perennial, monœcious, growing in tufts, dark-green above, nearly black below, $\frac{1}{8}$ in.–$\frac{3}{4}$ in. high, dichotomously branched, fastigiate. *Leaves* closely imbricating, erecto-patent or recurving, linear-lanceolate, obtuse, concave, slightly cucullate at the apex; margins entire; nerve keeled, ending close to the apex. *Areola:* Upper small, dense; lower quadrilateral; leaves crisp when dry. *Perichætial leaves* semi-convolute, about the size of the upper ones. *Fruit* acrocarpous. *Fruitstalk* erect or inclined, $\frac{1}{8}$ in. long. *Capsule* ovate. *Operculum* conico-rostrate; beak slender, straight, about two-thirds the length of the capsule. *Peristome* single; teeth 16, irregular, bi- or tri-fid, perforated. *Calyptra* mitriform, as long as the capsule, furred.

Hab. On rock on the north side of Mount Torlesse. Collected by R. Brown, January, 1900.

This is the only known habitat. Named after T. Turner, Esq., seed-merchant, Christchurch.

29. *G. barrii*, sp. nov. Plate XXXIX., fig. 29.

Plants perennial, monœcious, growing in small green tufts about $\frac{1}{4}$ in. high. *Stem* $\frac{1}{8}$ in. *Branches* arising below the perichætial leaves, $\frac{1}{8}$ in., fastigiate. *Leaves* closely imbricating, lower half of leaves oblong-lanceolate, upper half tapering into a subulate point, incurving in the upper part, subconvolute, acute; margins entire; nerve ending at the apex. *Areola:* Upper dense; lower quadrilateral; leaves crisp when dry. *Perichætial leaves:* Lower half erect, sheathing; upper half incurved. *Fruit* acrocarpous. *Fruitstalk* erect or inclined, $\frac{3}{16}$ in. long. *Capsule* narrow-turbinate, annulate. *Operculum* convex-rostrate, two-thirds the length of the capsule; beak long, slender. *Peristome* single; teeth 16, regular, entire, lanceolate. *Calyptra* mitriform.

Hab. On calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

Named after Peter Barr, V.M.H., F.R.H.S., M.R.A.S.

30. *G. hutchinsonii*, sp. nov. Plate XXXIX., fig. 30.

Plants perennial, monœcious, growing in small dense tufts $\frac{1}{4}$ in. high, yellowish-green. *Branches* $\frac{1}{16}$ in., fastigiate. *Leaves* small, erecto-patent, imbricating, oblong-lanceolate, tapering into a hyaline hair-point; margins entire; nerve keeled, ending at the hair-point; erect when dry. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* erect, larger than the stem leaves, hair-points longer. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{16}$ in. long, hygrometric, curved when moist, erect when dry. *Capsule* small, oval, annulate. *Operculum* conic. *Peristome* single; teeth 16, dark-red, shortly bifid at the apex. *Calyptra* small, mitriform.

Named after Mrs. Hutchinson, of Kirn, Scotland.

Hab. On calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

31. *G. kaikouraensis*, sp. nov. Plate XL., fig. 31.

Plants perennial, monœcious, growing in small dense tufts $\frac{1}{14}$ in. high. *Branches* short, fastigiate. *Leaves* closely imbricating, erecto-patent, recurved close to the apex, elliptic-lanceolate, acuminate, tapering into the hyaline hair-point; margins entire; nerve slender, ending at the hair-point; erect when dry. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* shorter and narrower than the stem ones, erect, sheathing the base of the fruitstalk, linear-acuminate, with a short hair-point. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{8}$ in. long, hygrometric at the middle. *Capsule* obovate or turbinate. *Operculum* conic or submammillate, one-third the length of the capsule. *Peristome* single; teeth 16, irregular. *Calyptra* small, cucullate.

Hab. On damp rocks near Kaikoura. Collected by R. Brown.

Genus **Tortula.**

32. *T. oamaruensis*, sp. nov. Plate XL., fig. 32.

Plants perennial, monœcious, gregarious, $\frac{3}{16}$ in. high, dark-green. *Branches* few, fastigiate. *Leaves* small, erecto-patent, slightly recurved, oblong, rounded at the apex, acute; margins recurved; nerve excurrent as an apiculus. *Areola:* Upper small, roundish; lower quadrilateral. *Perichætial leaves* erect, very small, broadly ovate, acuminate. *Fruit* acrocarpous. *Fruitstalk* $\frac{1}{8}$ in. long. *Capsule* small, ovate. *Operculum* conic, apiculate. Trace of the tube of a *peristome* was all that was found. *Calyptra* unknown.

Hab. On damp banks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

This plant was imperfect; it appears to be rare, but from its small size is easily overlooked.

33. *T. arida*, sp. nov. Plate XL., fig. 33.

Plants perennial, monœcious, growing in dense tufts, dark-brown, $\frac{1}{4}$ in. high. *Branches* arising from near the base, fastigiate. *Leaves* erecto-patent, closely imbricating, ovate-lanceolate, acute, slightly contracted in the middle with a minute hyaline point at the apex; margins entire; nerve stout, continued to the apex; crisp when dry. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* erect, shorter and narrower than the upper ones. *Fruit* acrocarpous. *Fruitstalk* red, $\frac{1}{4}$ in. long. *Capsule* cylindric, gibbous. *Operculum* nearly as long as the capsule, conico-rostrate; beak long. *Peristome* single, twisted; teeth one-third longer than the tube. *Calyptra* large, cucullate.

Hab. In small holes on calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

34. *T. oamaruana*, sp. nov. Plate XL., fig. 34.

Plants perennial, monœcious, growing in small dense tufts $\frac{1}{4}$ in. high, almost black. *Branches* fastigiate. *Leaves* closely imbricating, erecto-patent, lanceolate, acuminate, erect at the base; margins entire; nerve stout, continued to the apex, keeled; crisp when dry. *Areola:* Upper small, dense; lower large, quadrilateral. *Perichætial leaves* erect, nearly as large as upper stem ones, oblong-lanceolate, acuminate. *Fruit* acrocarpous. *Fruitstalk* $\frac{3}{16}$ in. long, stout. *Capsule* oblong, slightly curved, narrowed at the mouth. *Operculum* stout, conico-rostrate, slightly oblique, about half the length of the capsule. *Peristome* twisted, tube very short. *Calyptra* large, cucullate.

Hab. In small holes on calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

This plant differs from the preceding one in the acuminate leaves, the smaller capsule, shorter operculum, and the larger perichætial leaves.

35. *T. hutchinsonii*, sp. nov. Plate XL., fig. 35.

Plants perennial, monœcious, growing in dense tufts or small patches, dark-green, ⅛ in. high. *Branches* fastigiate. *Leaves* closely imbricating, erecto-patent, oblong, round at the apex or ligulate; margins entire or recurved; nerve stout, excurrent, has a long hyaline hair-point; crisp when dry. *Areola:* Upper small, dense; lower quadrilateral. *Perichætial leaves* about one-half shorter and narrower than the upper ones. *Fruit* acrocarpous. *Fruitstalk* ¼ in. long, red. *Capsule* cylindric, slightly curved, annulate, persistent. *Operculum* stout, conico-rostrate, slightly oblique, one-third the length of the capsule. *Peristome* twisted, tube very short. *Calyptra* cucullate.

Hab. In small holes on calcareous rocks near Weston, close to Oamaru. Collected by R. Brown, November, 1897.

EXPLANATION OF PLATES XXXV.-XL.

Plate XXXV.

Fig. 1. *Gymnostomum salmonii*, sp. nov.

1. Plant.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Lower.

Fig. 2. *G. brotherusii*, sp. nov.

1. Magnified one-half as much as capsule and leaves.
2. Capsule.
3. Calyptra.
4. Inner and outer perichætial leaves.
5. First leaf outside perichætial.
6. Upper leaves.
7. Middle leaf.

Fig. 3. *G. gibsonii*, sp. nov.

1. Capsule.
2. Inner and outer perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaf.
5. Middle leaf.
6. Lower leaf.

Fig. 4. *G. parisii*, sp. nov.

1. Capsule.
2. Perichætial leaves.

Fig. 5. *G. westlandicum*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 6. *Weissia kaikouraensis*, sp. nov.

1. Plant.
2. Mature capsule.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaf.
6. Middle leaf.

Plate XXXVI.

Fig. 7. *Weissia (?) searellii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaf.
5. Middle leaf.

Fig. 8. *Pottia whittonii*, sp. nov.

1. Plant.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaf.

Fig. 9. *Dicranum cardotii*, sp. nov.

1. Capsule.
2. Peristome.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaves.
6. Middle leaf.
7. Lower leaf.

Fig. 10. *D. waimakaririense*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaves.
6. Middle leaf.
7. Lower leaf.

Fig. 11. *D. kowaiense*, sp. nov.

1. Capsule.
2. Perichætial.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.
6. Lower leaves.

Fig. 12. *Trichostomum stanilandsii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaves.

Plate XXXVII.

Fig. 13. *T. kanieriense*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaf.
5. Middle leaf.
6. Lower leaf.

Fig. 14. *T. whittonii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 15. *T. theriotii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.
6. Lower leaf.

Fig. 16. *T. mokonuiense*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper stem leaves.
5. Peristome.
6. Middle stem leaf.

Fig. 17. *Orthotrichum oamaruense*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaf.
6. Middle leaf.

Fig. 18. *O. oamaruanum*, sp. nov.

1. Capsule.
2. Calyptra.
3. Peristome.
4. Perichætial leaves.
5. First leaf outside perichætial.
6. Upper leaf.

PLATE XXXVIII.

Fig. 19. *Orthotrichum beckettii*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaf.

Fig. 20. *O. otiraense*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaves.
6. Middle leaves.

Fig. 21. *Bryum foresterii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.
6. Lower leaf.

Fig. 22. *B. whittonii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.
6. Lower leaf.

Fig. 23. *B. barrii.*

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaves.

Fig. 24. *B. theriotii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaf.
5. Middle leaf.

PLATE XXXIX.

Fig. 25. *Blindia theriotii*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaves.
6. Middle leaves.

Fig. 26. *B. (?) torlessensis*, sp. nov.

1. Immature and matured capsule.

Fig. 27. *Grimmia (Schistidium) oamaruense*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 28. *G. turnerii*, sp. nov.

1. Capsule.
2. Calyptra.
3. Peristome.
4. Perichætial leaves.
5. First leaf outside perichætial.
6. Upper leaves.

Fig. 29 *G. barrii*, sp. nov.

1. Capsule.
2. Calyptra.
3. Peristome.
4. Perichætial leaves.
5. First leaf outside perichætial.
6. Upper leaf.
7. Middle leaf.

Fig. 30. *G. hutchinsonii*, sp. nov.

1. Capsule.
2. Calyptra.
3. Perichætial leaves.
4. First leaf outside perichætial.
5. Upper leaf.
6. Middle leaf.

PLATE XL.

Fig. 31. *Grimmia kaikouraensis*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 32. *Tortula (?) oamaruensis*, sp. nov.

1. Capsule.
2. Perichætial.
3. First leaf outside perichætial.
4. Upper leaf.
5. Middle leaf.

Fig. 33. *T. arida*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 34. *T. oamaruana*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.
5. Middle leaf.

Fig. 35. *T. hutchinsonii*, sp. nov.

1. Capsule.
2. Perichætial leaves.
3. First leaf outside perichætial.
4. Upper leaves.

ART. XLI.—*Structure of Leaf of certain Species of Coprosma.*

By Miss N. A. R. GREENSILL, M.A.

[*Read before the Philosophical Institute of Canterbury, 3rd September, 1902.*]

Plates XLI.-XLIV.

THE *Coprosmas* are interesting subjects for examination, for all, except some of the small-leaved species, are distinguished by the presence on their leaves of little pits opening on the under-surface of the leaf, and marked on the upper by a protuberance.

Coprosma baueri. Endlicher, Iconog., Gen. Pl., t. iii.

The leaf, the underside of which is represented in fig. 4, has reticulate venation. In the axils of the midrib (*m.*) and primary veins (*p. v.*) appear the pits (*p.*), which are thus arranged with considerable regularity (see also fig. 3). In one or two leaves I saw one, or sometimes two or three, pits in the axils of the secondary veins, but this was of unusual

occurrence. On the upper side of the leaf the presence of the pits is denoted by well-marked protuberances. The structure of the leaf and tissues round the pit (fig. 1) is as follows: In transverse section on the upper surface of the leaf there is first a cuticle (*cu.*) with an irregular outline; beneath this a layer of small epidermal cells (*ep.*); next a hypodermal layer of colourless, roundish cells, elongated in a transverse direction, and functioning as a storage layer for water (*st. l.*); beneath this again a layer of cells (*ho.*) approximating to the storage layer, but containing in parts a few chlorophyll granules, though in other parts they are quite empty. This layer is longer than broad, thus approaching in shape the palisade cells (*p. p.*) of the next few rows. These palisade cells, which are typically elongated in a longitudinal direction, contain a great number of chlorophyll corpuscles (*chl.*), crowded rather closely together towards the centre. They also contain, in almost all the species examined, drops (*d.*) of what appeared to be oil. Beneath the cells of the palisade parenchyma are those of the spongy parenchyma (*sp.*) of irregularly shaped cells, with numerous air-spaces between. They also contain numerous chlorophyll corpuscles (*chl.*), though not so many nor so closely crowded as those of the palisade parenchyma. In the spongy parenchyma, too, in all the species I examined I found numerous bundles of crystals or raphides (*r.*). Beneath the spongy tissue, which occupied the greater part of the leaf-area, is the epidermis of the lower surface (*l. ep.*), in which are numerous stomata (*st.*). On the lower surface there is also a cuticle (*cu.*) with the same irregular outline as that of the upper surface. The stomata are enclosed by two guard-cells (*g.*), in transverse section smaller and different in shape from the ordinary epidermal cells. The epidermal cells next to the guard-cells are modified to form subsidiary cells (*s.*), into which the guard-cells fit, and which overhang the guard-cells. The pit is circular in outline, with projecting rims. Its epidermis (*p. ep.*) is continuous with that of the lower surface, and similar to it. Above the pit epidermis are two layers of roundish cells (*c. l.*), slightly elongated in a transverse direction, and colourless in contrast with the spongy tissue immediately surrounding the innermost layer. A few of the epidermal cells are occasionally prolonged into papillose projections or hairs (*h.*), which are usually unicellular, though I saw one such hair consisting of two cells. These hairlike projections are not very numerous, and many pits appeared to be without them. Dr. A. N. Lundström regards these pits as hairless. There are no stomata in the pits either of this species or any of the other species I examined. The vascular bundle (*v. b.*) of the midrib is seen beside the pit, with xylem

above and phloem beneath. It has the usual structure, and is accompanied by parenchymatous cells (*par.*) and the leaf-sheath (*l. s.*). Above the xylem are a few round chlorophyll-containing cells (*ch.*), with few chlorophyll corpuscles (*chl.*). They are inserted between the xylem and the parenchyma cells of the upper part of the leaf. In sections that have been stained it is seen that the hairs and epidermis of the pit and the colourless layers inside the epidermis have all living protoplasmic contents. This was the case in every species examined, in which all or any of these cells were present.

Fig. 3 is a surface section of the pit showing the stomata in surface view, and the position of the pit between the midrib (*m.*) and the primary veins. The epidermis of the pit (*p. ep.*) is seen, the hairs (*h.*), and the colourless layers (*c. l.*) inside the epidermis. The characters already mentioned are thus repeated in this section, though the shape of the cells differs in correspondence to the different direction in which the section was cut.

Coprosma lucida. Forster, Char. Gen., 138.

The pits (*p.*) are situated in the axils of the midrib (*m.*) and primary veins, and occur with great regularity. I saw none in the axils of the secondary veins. The two leaves figured (figs. 5 and 11) are both varieties of this species. The structure of the tissues as seen in transverse section (fig. 6) is as follows: On the upper surface of the leaf a thick cuticle (*cu.*) with a wavy outline; an epidermal layer (*ep.*) of narrow cells elongated in a transverse direction; then a hypodermal layer of roundish cells (*st. l.*), also elongated in a transverse direction, and serving as a storage layer for water; then two or three layers of typical palisade cells (*p.p.*), with chlorophyll corpuscles (*chl.*) and drops of oil (*d.*). The chlorophyll corpuscles in this case are less crowded, though still numerous. Next comes typical spongy parenchyma (*sp.*) of irregularly shaped cells, with chlorophyll corpuscles scattered in them. This, as usual in all the species, occupied the greatest thickness of the leaf. Below this is the epidermis of the lower surface (*l. ep.*), the cells of which are smaller and broader than those of the upper; then a cuticle, thinner, but with the wavy outline of that on the upper surface. In the lower epidermis are numerous stomata (*st.*) with small guard-cells (*g.*), and subsidiary cells (*s.*), not so unlike ordinary epidermal cells. The cuticle forms a projection (*p.*) at the entrance of the stoma, thus narrowing it and diminishing the rate of transpiration. The epidermis (*p. ep.*) and cuticle (*cu.*) of the pit are continuous with and similar to those of the lower surface. There are numerous multicellular hairs (*h.*) in the pit or at its mouth. The individual cells of these

hairs are almost as broad as long; their number varies. Fig. 9 shows one of these hairs stained with eosine. The nuclei (*n.*) and protoplasmic contents are then clearly seen. In the young pit the hairs are unicellular, as in fig. 10. Next to the epidermis are two layers of colourless round cells (*c. l.*), next to which again is the ordinary spongy parenchyma of the leaf. The chlorophyll cells that are present in the projecting rims of the pit have fewer corpuscles, and are sometimes almost colourless. This was the case in all the species I examined. All the pits, too, had the same projecting rims and circular outline.

Coprosma propinqua. A. Cunningham, Precurs., n. 472.

Fig. 22 shows the under-surface of a leaf of this species, which, however, is rather broader-leaved than usual. The pits are few in number; sometimes one, sometimes two, and occasionally none are present. The pits (*p.*) are in the axils of the midrib (*m.*) and primary veins. The veins also are few in number, as visible to the naked eye. The structure of the leaf in transverse section (fig. 8) is as follows: On the upper surface a rather thick cuticle (*cu.*) with minute irregular projections; an epidermis (*ep.*) of very large cells, almost square in shape, which themselves can function as a storage layer for water; then two or three layers of palisade cells with the usual contents, the chlorophyll corpuscles being irregularly scattered. Then comes the spongy tissue of the leaf, of the usual typical form, with slightly less numerous corpuscles than the palisade cells; below that the epidermis of the lower surface (*l. ep.*), of much smaller cells than that of the upper, and with a thinner cuticle (*cu.*), which, however, has the same irregular outline. In the lower epidermis are numerous stomata (*st.*), which have much the same form as those of *Coprosma lucida*, only the cuticle does not project so much in front of the opening. The guard-cells (*g.*) are pear-shaped, and the epidermal cells (*s.*) next to them are slightly modified to fit into them. The epidermis of the pit (*p. ep.*) is like that of the lower surface, though, of course, there are no stomata; the cuticle (*cu.*) has a very irregular outline. In the pit are hairs (*h.*) of two, three, or sometimes more cells. The individual cells of the hairs in this case are long and narrow.

Coprosma linearifolia. Hook. f., Handbk., 118.

The upper and lower surfaces of the leaf are seen in fig. 23. The upper surface shows no venation to the naked eye; the lower surface only the midrib and one or two primary veins. The pit (*p.*) on the under-surface has a tiny opening; on the upper a marked protuberance (*pro.*). The pits ap-

peared mostly near the end of the leaf, in the axil of the midrib, and veins not visible to the naked eye. They are usually two in number, placed opposite to one another; but sometimes there are no pits at all present. The structure of the leaf in transverse section is seen in fig. 14. The leaf is very similar to that of *Coprosma propinqua*. On the upper surface a cuticle with a surface slightly irregular; an epidermis of large cells, almost square in shape, that may function as a storage layer (*ep.*); two or three layers of typical palisade parenchyma (*p. p.*), with the usual contents, the chlorophyll corpuscles (*chl.*) being irregularly scattered; then typical spongy parenchyma (*sp.*), with less numerous though still many corpuscles, also irregularly scattered; then the epidermis of the lower surface (*l. ep.*) of much smaller cells; a cuticle (*cu.*) with a wavy outline; and numerous stomata (*st.*), with pear-shaped guard-cells (*g.*), and slightly modified subsidiary cells (*s.*). There are, however, no hairs present in the pit. Next to the epidermis of the pit (*p. ep.*), which is similar to that of the lower surface, and has a cuticle (*cu.*) with the same wavy outline, is a single layer of roundish colourless cells (*c. l.*); next to that a layer (*x.*) of cells approximating to these in shape, but containing a few chlorophyll corpuscles. These cells are intermediate between the colourless layer and the spongy parenchyma which surrounds them.

Coprosma fœtidissima. Forst., Char. Gen., 138.

The upper and lower surfaces of the leaf are shown in fig. 24. The pits are few in number, and are situated in the axils of the midrib (*m.*) and primary veins. On the lower surface no veins are visible to the naked eye, and the opening of the pit (*p.*) appears to be very small. On the upper surface a slight protuberance (*pro.*) is seen, as well as the primary veins (*p. v.*). The structure of the leaf in transverse section is as follows (fig. 15): On the upper surface a cuticle (*cu.*) with a wavy outline; an epidermis (*ep.*) of cells slightly elongated in a transverse direction; beneath that a layer of cells (*ho.*) intermediate between a hypodermal storage layer and the palisade cells. They are like the palisade cells in shape, but contain very few chlorophyll corpuscles. Beneath them are two or three layers of palisade cells (*p. p.*), with numerous chlorophyll corpuscles (*chl.*) massed together in the middle of the cells as almost globular aggregates. These cells are broader than are those of the species hitherto described. Below them comes typical spongy parenchyma, with less numerous chlorophyll corpuscles irregularly scattered; and on the lower surface is an epidermis (*l. ep.*) of small cells, with a thin cuticle (*cu.*) and numerous stomata (*st.*). The

guard-cells (*g.*) are small and pear-shaped; the subsidiary cells (*s.*) are slightly modified to fit into them. The cuticle does not show the wavy outline of the upper surface. The pit has numerous unicellular hairs (*h.*) inside and at the opening; they are outgrowths of epidermal cells. Next to the pit epidermis are two layers of roundish cells (*c. l.*), slightly elongated in a transverse direction, and colourless. Next to these is a layer (*x.*) of cells, intermediate in shape between the colourless layers and the cells of the spongy parenchyma, and containing very few chlorophyll corpuscles. Above this again is the spongy tissue of the leaf.

Coprosma chathamica. Cockayne, Trans. N.Z. Inst., xxxiv., p. 317.

The under-surface of the leaf is shown in fig. 13. The pits (*p.*) occur regularly in the axils of the midrib and primary veins. The venation is reticulate. The upper surface of the leaf has only a slight protuberance marking the presence of the pits. The structure of the leaf in transverse section (fig. 16) is as follows: On the upper surface a rather thick cuticle (*cu.*) with slightly wavy outline; an epidermal layer (*ep.*) of cells elongated in a transverse direction; a storage layer (*st. l.*) of roundish cells, also elongated in a transverse direction; two or three layers of typical palisade tissue (*p. p.*), with chlorophyll corpuscles arranged regularly around the walls of the cells. Beneath the palisade tissue is typical spongy parenchyma (*sp.*), the cells of which are less irregular in shape than are those of all the species already described. They contain chlorophyll corpuscles, also arranged, though with less regularity, along the walls of the cells. On the lower surface is an epidermis (*l. ep.*) of smaller cells, with a thinner cuticle. The epidermis of both the upper and lower surfaces has numerous outgrowths or hairs (*h.*), usually unicellular. There are numerous stomata (*st.*) on the lower surface, which do not differ from those already described. The epidermis of the pit (*p. ep.*), which is similar to the epidermis of the lower surface, is a single layer of colourless cells (*c. l.*), round in shape; next to that is a layer (*x.*) intermediate in shape between the colourless layer and the cells of the spongy parenchyma, and containing very few chlorophyll corpuscles. The hairs (*h.*) of the pit are long and multicellular; the individual cells of the hairs are narrow and elongated.

Coprosma petiolata (Chatham Island variety). Hook. f., in Journ. Linn. Soc., Bot., i. (1857), 128.

The under-surface of the leaf is seen in fig. 12. The pits (*p.*) are arranged with considerable regularity in the axils of

the midrib (*m.*) and primary veins. The venation is reticulate, the leaf thin and hairy, and the pits (*p.*), with tufts of hairs projecting from the opening, easily visible to the naked eye. The structure of the leaf in transverse section is very similar to that of *Coprosma chathamica.* It is seen in fig. 17. On the upper surface a cuticle (*cu.*) with slightly irregular outline; an epidermis (*ep.*) of cells elongated in a transverse direction; two or three layers of typical palisade cells (*p. p.*), with chlorophyll corpuscles (*chl.*) arranged regularly along the walls of the cells; below that spongy tissue, the cells of which are rounded, and scarcely irregular at all in shape. They contain chlorophyll corpuscles arranged along the walls of the cells. On the lower surface is an epidermis (*l. ep.*) of smaller cells, with a thin cuticle. The layer of cells next to the epidermis contains very few chlorophyll corpuscles. On the lower surface are numerous stomata (*st.*) with pear-shaped guard-cells (*g.*), and slightly modified subsidiary cells (*s.*). There are many hairs (*h.*) at the mouth of the pit, which project in tufts. They are multicellular, and some are very long; the individual cells of the hairs are elongated and narrow. The epidermis (*p. ep.*) and cuticle are similar to those of the lower surface. Next to the pit epidermis are two layers of colourless cells (*c. l.*), roundish in shape, and slightly elongated in a transverse direction. In this case the layer (*x.*) of *Coprosma chathamica* has been fully modified to form a second colourless layer. Around these colourless cells is the spongy tissue of the leaf. There are hairs (*h.*) also within the pit, but they are not so numerous nor so long as those at the opening. On the upper and lower surfaces of the leaf also there are numerous hairs, mostly two-celled, though they may consist of more cells, or be unicellular. They are especially numerous proceeding from the epidermis next to the parenchymatous cells (*par.*) surrounding a vascular bundle. Both of these Chatham Island species have less projecting rims to their pits.

Coprosma robusta. Raoul., in Ann. Sc. Nat., ii. (1844), 121.

The under-surface of the leaf is shown in fig. 19. The venation is reticulate. The pits (*p.*) are regularly arranged in the axils of the midrib (*m.*) and primary veins. On the upper surface their presence is indicated by a well-marked protuberance. The structure in transverse section (fig. 18) is as follows: On the upper surface a rather thick cuticle (*cu.*) with slightly irregular outline; an epidermis (*ep.*) of roundish cells, large and elongated in a transverse direction, and probably serving to store up water in addition to their other functions. Beneath the epidermis are two or three layers of typical palisade cells with the usual contents, the chloro-

phyll corpuscles (*chl.*) being rather closely crowded, especially towards the centre; beneath the palisade parenchyma is typical spongy parenchyma (*sp.*), with numerous chlorophyll corpuscles (*chl.*) scattered irregularly. On the lower surface is an epidermis of small roundish cells (*l. ep.*), with a thinner cuticle than that of the upper, and numerous stomata. The guard-cells (*g.*) project slightly, are small and pear-shaped; the subsidiary cells (*s.*) are slightly modified epidermal cells. The epidermis of the pit (*p. ep.*) is similar to that of the lower surface, and has a cuticle (*cu.*). There are numerous projecting hairs (*h.*) consisting of two or three narrow elongated cells. Next to the epidermis are two layers of round colourless cells (*c. l.*), and around these is the spongy tissue of the leaf.

Coprosma cunninghamii. Hook. f., Handbk., 113.

The under-surface of the leaf is seen in fig. 20. The pits (*p.*) are arranged regularly in the axils of the midrib (*m.*) and primary veins. The structure of the leaf in transverse section (fig. 25) is as follows: On the upper surface a cuticle (*cu.*) with slightly irregular outline; next an epidermis (*ep.*) of rather large cells elongated in a transverse direction; beneath these two or three layers of typical palisade cells with the usual contents, and the chlorophyll corpuscles (*chl.*) rather closely crowded; beneath this, again, typical spongy parenchyma (*sp.*), with less crowded though still numerous chlorophyll corpuscles; then the epidermis of the lower surface (*l. ep.*), consisting of small cells, and with a cuticle (*cu.*) and numerous stomata (*st.*). The guard-cells (*g.*) are pear-shaped as usual, the subsidiary cells (*s.*) slightly modified to fit into them. There are numerous hairs (*h.*) at the opening of the pit, as well as inside. They are multicellular, the individual cells of each being narrow and elongated. The epidermis of the pit (*p. ep.*) is similar to that of the lower surface. In immediate contact with it is the spongy tissue of the leaf, no colourless layers being present inside the epidermis.

Coprosma rotundifolia. A. Cunn., Precurs., n. 472.

The under-surface of the leaf is seen in fig. 21. The pits are few in number, arranged in the axils of the midrib (*m.*) and primary veins. The leaf is thin. The structure in transverse section (fig. 26) is as follows: On the upper surface of the leaf is a thin cuticle (*cu.*) and numerous hairs composed of two or three narrow elongated cells; an epidermal layer (*ep.*) of large cells, elongated in a transverse direction, and probably able to function as a storage layer for water. Beneath this there are two or three layers of palisade cells (*p. p.*), broader than usual, and with their numerous chlorophyll

corpuscles (*chl.*) closely crowded in the centre. The last layer of the palisade tissue contains fewer though still many corpuscles, and is intermediate in shape between the cells of the palisade and spongy parenchyma. Next to the layer is the typical spongy tissue (*sp.*) of the leaf, with fewer chlorophyll corpuscles (*chl.*) irregularly arranged in the cells. On the lower surface there is an epidermis (*l. ep.*) with hairs (*h.*) and numerous stomata (*st.*). The cells of the epidermis are smaller than are those of the upper surface, and are protected by a thin cuticle (*cu*). The hairs consist of several cells, elongated and narrow, and are similar to the hairs of the pit. The epidermis of the pit (*p. ep.*) is like that of the lower surface, but the cells are slightly larger. Above and around it is the spongy parenchyma of the leaf, with no intervening layer of colourless cells. The stomata of the lower surface have rather small guard-cells (*g.*), and slightly modified subsidiary cells (*s.*).

The structure of the leaf and tissues surrounding the pits is seen to be essentially the same in all these species. In all cases the leaves have a typical dorsiventral structure, with palisade and spongy parenchyma, showing only slight modifications in the shape of their cells and the number and arrangement of the chlorophyll corpuscles they contain. The cuticle varies in outline and thickness; the stomata in the shape of the guard-cells, the subsidiary cells, and the size of the stomatal opening. The absence of a hypodermal storage layer is usually compensated for by an enlarged epidermis; when present this layer is seen, on staining, to have living protoplasmic contents. Some species have cells which appear to be in course of differentiation into this layer, as the layer (*ho.*) of figs. 1 and 15. Others, again, seem to have a colourless layer in course of differentiation from the spongy tissue around the pit, as layer (*x.*) of figs. 14, 15, and 16. There may be one or two of these colourless layers already present. Finally, the hairs of the pits differ in the number and shape of their cells. They are in all cases outgrowths of epidermal cells, covered with a thin layer of cuticle. But the essential features are the same in all cases.

Development of the Pits.

I examined very young leaves only in the case of *Coprosma baueri* and *Coprosma lucida*. Fig. 2 shows a transverse section of a young pit of the former, fig. 7 of the latter. The pit begins as a shallow indentation, which gradually grows deeper, and finally becomes partially roofed in by the extension of the surrounding tissue of the leaf.

Fig. 2 (stained with eosine): The upper (*ep.*) and lower epidermis (*l. ep.*) consist of small tightly packed cells, with

no cuticle and with thin walls. The differentiation into palisade and spongy parenchyma at this stage is scarcely more than indicated in the chlorophyll tissue (*ch.*) by those cells which will become palisade parenchyma being more tightly packed and less rounded off. The layer beneath the upper epidermis has no chlorophyll corpuscles, thus marking the differentiation into a hypodermal layer. The two or three layers surrounding the pit consist of smaller cells very tightly packed. The cells lining the pit (*p. ep.*) are longer in shape than those of the epidermis of both surfaces. Some are almost papillose, though there are no hairs to be seen at this stage. The mesophyll of the leaf contains very few chlorophyll corpuscles, and there are numerous bundles of crystals (*r.*) contained in the individual cells. In this section the nuclei (*n.*) of all the cells are shown. Close beside the pit is seen the vascular bundle (*v. b*) of the midrib, with parenchymatous cells (*par.*) above and below. These parenchymatous cells also contain numerous raphides (*r.*).

Fig. 7: The main features are similar to those seen in fig. 2. This section, however, is unstained. There is an upper (*ep.*) and a lower (*l. ep.*) epidermis of tightly packed cells, somewhat larger than those of *Coprosma baueri*, but with no cuticle. The differentiation into palisade and spongy parenchyma is indicated by those cells which ultimately form the palisade tissue (*p. p.*) being narrower and less rounded in form. There are few chlorophyll corpuscles present in the mesophyll of the leaf, and they are much smaller than in the mature leaf. Crystals (*r.*) are present here also. The differentiation into a hypodermal layer is shown also in this case by the absence of chlorophyll. The epidermis of the pit is very similar to that of the lower surface. There is a tuft of unicellular hairs (*h.*) in the pit. The two or three layers around the pit are here also closely packed, and smaller than the remaining cells of the leaf. They contain few or no chlorophyll corpuscles, as was also the case in *Coprosma baueri;* and in the mature leaf will be the colourless layers inside the pit epidermis.

NATURE OF THE PITS.

Dr. A. N. Lundström examined these structures in many different species of plants, and was the first who made thorough investigations into their nature. A summary of his report was published in the "Journal of the Royal Microscopical Society" (1888). A paper was also written on the subject of "domatia" by Mr. Alex. G. Hamilton, which was published in a number of the "Proceedings of the Linnæan Society of New South Wales" (1896). In the species he described was included *Coprosma lucida.* Dr. Lundström re-

garded these pits as coming under the head of "domatia," and discussed four interpretations that might be put upon them: (1) They may be pathological; (2) they may have only an indirect connection with their tenants; (3) they may be for catching insects; (4) they may be of use to the plant as the dwellings of commensals. He adopts this last interpretation regarding the pits as being the result of a symbiosis between the plant and minute Acarids, which are supposed to make them their homes. He appears to have always found Acarids in possession of these cavities. Mr. Hamilton says that as often as not he found no mites there, and in two instances in which he found large numbers of them the pits were damaged by their presence. In these damaged pits he found "brownish patches here and there, and also in places a number of the cells were of a bright-crimson colour." I have avoided calling these pits "domatia," for they do not seem to me to come within the definition of such as given by Dr. Lundström—*i.e.*, "those formations or transformations in plants adapted to the habitation of guests, whether animal or vegetable, which are of service to the plant."

In all the species of *Coprosma* I examined I found not a single trace of an Acarid in the pits. As some of these species were obtained from the Christchurch Botanical Gardens, or from private gardens, I thought that this might be accounted for by the fact of their not growing naturally in the bush; but in specimens obtained from the bush at Dunedin I found the same state of affairs. In several of the species the tissues round the pits were in an unhealthy condition, with brownish patches here and there, and some cells of a bright-crimson colour, just as described by Mr. Hamilton. There were, however, no Acarids present in such pits. I invariably found in these cases what appeared to be the hyphæ of some fungus growing between the cells of the leaf-tissue. The crimson cells were round in outline, and looked very much like spores, and some seemed to be in the act of germinating. In the cavity of the pits I frequently found quantities of dust or other foreign matter collected, as did also Dr. Lundström. The unhealthy state of the pits seemed to me to be due to the attacks of some fungal parasite. The cells of the leaf between which the hyphæ grew were not at all swollen or distorted. The unhealthy condition, too, was by no means confined to the tissue around the pits, but occurred in all parts of the leaf, so that it could scarcely have been due to the presence of Acarids in the pits, though, of course, the injurious effect of such presence would tend to overthrow Dr. Lundström's theory as to their utility to the plant. As these mites appear to take refuge in any suitable cavity (Mr. Hamilton found them in rolled leaves of *Ricino-*

carpus, in the stomatal crypts of *Banksia*, and other cracks and cavities suitable for shelter), their occasional presence in the pits may be accounted for by the fact of these pits presenting a suitable place for shelter. Therefore I incline to think that there is no connection between the formation of the pits and the visits of the insects.

Mr. Hamilton also in his paper discusses and dismisses the probability of the pits being pathological in nature; being glands; being cavities for sheltering stomata; or being extra growths caused by the superabundance of sap. As these suppositions have been sufficiently discussed, I will merely notice in passing the following facts in reference to them: There was no sign of any diseased condition of the leaf-tissues, except in the case already mentioned; there was no sign of any secretion from the hairs or epidermal cells of the pits; there were no stomata in any of the pits. Mr. Hamilton mentions, finally, the possibility of these pits being organs for the absorption of water or vapour, and dismisses this theory also owing to his inability to fill the pits with water. I tried first to fill the pits with an alcoholic stain, as did Mr. Hamilton, and succeeded without any difficulty. The epidermal cells and hairs of the pit in a few minutes showed a faint tinge of the colour of the staining material in their cells. But, lest the alcohol should affect the absorbing-capacity of the living cells in any way, I tried covering the surface of the leaf with water in which was mixed finely powdered carmine. After leaving it for a short time on the surface of the leaf I washed off all traces of the carmine, so that in the action of cutting I might not introduce any of it into the pits. I then cut sections through the pits, and found that there were numerous grains of carmine adhering to the cells of the epidermis and hairs of the pit. The hairs may serve especially to suck up water, though the epidermis probably aids in the process, for in *Coprosma linearifolia* there are no hairs in the pits, and in some other species they are not numerous enough to be of themselves of great importance. The presence of a cuticle outside the epidermal cells and hairs need be no hindrance to the theory of the pits as absorbing organs, for it is not often thick. A cuticle, unless very thick, is not impermeable to water; and even when very thick it is not so much its thickness that prevents the absorption of water through it, but the presence of and amount of wax in the cuticle, and the contents of the cells it covers. As to the contents of the cells, I can say nothing for certain. I could see in the hairs, in the cells of the colourless layers, and the epidermis of the pit, minute or larger round bodies, some of which may have been drops. They were clear and transparent looking. I could also see these in the cells of the hypo-

dermal layers of the upper surface, which serve to store up water. The colourless layers around the pits, when present, would serve to store up the water absorbed by the epidermal cells and hairs. These epidermal cells and hairs could not absorb water if empty of living contents; but this is not the case, as they contain protoplasm and nuclei. This is the case also with the colourless layers. The tufts of hairs at the opening of the pits of *Coprosma petiolata* may serve to suck up water without it actually entering the pit. Again, the position of the pits, between the midrib and veins of the leaf, is well adapted to the taking-up of water by the vascular bundles of the leaves, and its transference in this way to the different parts of the leaf. The position of the pits, of course, opening on the under-surface of the leaf, is not favourable to the absorption of water; but the absorption cavities of other plants which are similarly situated can absorb water without any difficulty in spite of the position—*e.g.*, the leaf of the cowberry (*Vaccinium vitis-idæa*). The presence of dust and other foreign matters in the pit cavities, too, seems to indicate that it was washed there by the rain.

Lettering used in Figures.

cu. Cuticle.
ep. Epidermis of upper surface.
st. l. Storage layer.
ho. Layer approximating to storage layer.
chl. Chlorophyll corpuscle.
d. Oildrop.
p. p. Palisade parenchyma.
r. Raphides.
ch. Chlorophyll-containing tissue.
sp. Spongy parenchyma.
l. ep. Epidermis of lower surface.
st. Stoma.
g. Guard-cell.
s. Subsidiary cell.
h. Hair.
p. ep. Epidermis of the pit.
c. l. Colourless layer inside pit epidermis.
x. Layer approximating to colourless layer.
pn. Projection of cuticle.
par. Parenchyma.
v. b. Vascular bundle.
l. s. Leaf-sheath.
p. v. Primary vein.
m. Midrib.
p. Pit.
pro. Protuberance.
n. Nucleus.

EXPLANATION OF PLATES XLI.-XLIV.

Plate XLI.

Fig. 1. Transverse section, leaf and pit of *C. baueri.*
Fig. 2. Transverse section, young leaf and pit of *C. baueri.*
Fig. 3. Surface section, leaf and pit of *C. baueri.*
Fig. 4. Under-surface leaf of *C. baueri:* life size.
Fig. 5. Under-surface leaf of *C. lucida:* life size.

Plate XLII.

Fig. 6. Transverse section, leaf and pit of *C. lucida.*
Fig. 7. Transverse section, young leaf and pit of *C. lucida.*
Fig. 8. Transverse section, leaf and pit of *C. propinqua.*
Fig. 9. Longitudinal section through hair from pit of *C. lucida* (stained).

Fig. 10. Longitudinal section from young pit of *C. lucida* (unstained).
Fig. 11 Under-surface leaf of *C. lucida:* life size.
Fig. 12. Under-surface leaf of *C. petiolata:* life size.
Fig. 13. Under-surface leaf of *C. chathamica:* life size.

PLATE XLIII.

Fig. 14. Transverse section, leaf and pit of *C. linearifolia.*
Fig. 15. Transverse section, leaf and pit of *C. fœtidissima.*
Fig. 16. Transverse section, leaf and pit of *C. chathamica.*
Fig. 17. Transverse section, leaf and pit of *C. petiolata.*

PLATE XLIV.

Fig. 18. Transverse section, leaf and pit of *C. robusta.*
Fig. 19. Under-surface leaf of *C. robusta:* life size.
Fig. 20. Under-surface leaf of *C. cunninghamii:* life size.
Fig. 21. Under-surface leaf of *C. rotundifolia:* life size.
Fig. 22. Under-surface leaf of *C. propinqua:* life size.
Fig. 23. (*a.*) Under-surface leaf of *C. linearifolia:* life size. (*b.*) Upper surface same.
Fig. 24. (*a.*) Upper-surface leaf of *C. fœtidissima:* life size. (*b.*) Under-surface same.
Fig. 25. Transverse section, leaf and pit of *C. cunninghamii.*
Fig. 26. Transverse section, leaf and pit of *C. rotundifolia.*

ART. XLII.—*On some Recent Changes in the Nomenclature of the New Zealand* Myrsinaceæ.

By L. COCKAYNE.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

THE ninth part of Engler's "Pflanzenreich,"* containing the *Myrsinaceæ* by Dr. Carl Mez, Professor of Botany in the University of Halle, has recently appeared. The object of this paper is to publish for the benefit of such New Zealand botanical students as have not access to the above-mentioned most important work an account of certain changes in nomenclature which affect the New Zealand species, since "Das Pflanzenreich" will, in all probability, be the authority on plant-nomenclature for many years to come.

The natural order *Myrsinaceæ*, according to Mez, contains thirty-two genera, including 933 species, of which 348 are described for the first time. Of these genera, two occur in New Zealand—viz., *Suttonia* and *Rapanea*. Mez divides *Suttonia* into two subgenera, *Eusuttonia* and *Rapaneopsis*. *Eusuttonia* contains six species, if the species now known as *Myrsine coxii* be added, which are all confined to the New

* Engler, A., Das Pflanzenreich. Regni vegetabilis conspectus 9. Heft (iv. 236). Myrsinaceæ mit 470 einzelbildern in 61 figuren. Carl Mez. Leipzig, 1902.

Zealand biological region, if *S. tenuifolia*, a doubtful species from Norfolk Island, be excluded; while *Rapaneopsis*, containing eight species, is found only in the Sandwich Islands. As for *Myrsine*, the genus to which all the New Zealand *Myrsinaceæ* are referred in the "Handbook of the New Zealand Flora," it contains, according to Mez, only four species, which are Asiatic or African. *Rapanea*, the genus to which the remainder of the New Zealand *Myrsinaceæ* are referred by Mez, contains 136 species, for the most part previously referred to *Myrsine*, and found in both the Northern and Southern Hemispheres, chiefly in the tropics. The following are the diagnoses of the genera *Myrsine*, *Suttonia*, and *Rapanea*, together with their synonyms, copied verbatim from "Das Pflanzenreich," and afterwards is given a list of the New Zealand species of the *Myrsinaceæ* and their synonyms.

Myrsine, L.

Myrsine, L., Gen. (1737) 54 et Spec. pl. ed. 1 (1753) 196; Willd. Spec. pl. 1 (1797) 1121; Gaertn. Fruct. 1, 281; R. Br. Prodr. 1 (1810) 533 et post eum omnes sequentes pro minima parte; Endl. Gen. (1836-40) n. 4221 p. 736; Benth. and Hook. f. Gen. ii. (1876) 642; Pax in Engl. et Prantl. Pflzfam. iv. 1 (1889) 92.

Flores reductione sexus alterius dioici, 4-vel 5-meri. Sepala libera vel basi brevissime coalita, imbricata vel per anthesin saltem sæpius aperta, margine ciliata vel rarissime nuda, punctato-picta. Petala basi brevissime vel breviter vel rarissime medium usque coalita, imbricata, margine sæpius ciliata, punctata. Stamina petalis longiora vel breviora; filamentis permanifestis, longe nunc longuiscule liberis, petalis prope basin insertis sueto annulo glanduloso insidentibus; antheris paullo super basin dorsifixis, liberis, rimis binis tota longitudine introrsum dehiscentibus, apice fere constanter apiculatis. Ovarium glabrum, ovoideum vel ellipsoideum; stylo constanter manifesto nonnunquam perlongo petala superante; stigmate maximo, disciformi vel margine foliaceo-inciso. Placenta uniseriatim perpauciovulata. Fructus globosus, 1-spermus, baccatus; endocarpio crustaceo. Semen globosum, placentæ reliquiis indutum; albumine corneo, crasse ochraceo-ruminato; embryone cylindrico, transverso. Frutices nani vel altiores vel arbores foliis sparsis, sæpissime serratis vel crenatis. Inflorescentiæ laterales, axillares vel e ligno bienni provenientes, in ramulorum brevissimorum verruciformium sæpius subnullorum apice umbellatæ, pauciflorsæ. Flores parvi, pedicellati.

Genus hic depuratum et ad species reductum a Rapanea, cui erat confusum, toto cœlo differt et Embeliæ imprimis †Micrembeliæ proprius accedit.

Suttonia, Hook. f.

Suttonia, Hook. f. (non! A. Rich.), Bot. of the Antarc. Voy. i. (1845) 49 et Fl. Nov. Zeland. i. (1853–55) 172; Pax in Engl. and Prantl. Pflzfam. iv. 1 (1889) 91.

Flores hermaphroditi vel reductione sexus alterius dioici, 4-vel 5-meri. Sepala basi breviter nunc brevissime coalita vel libera, imbricata vel aperta, margine ciliolata. Petala plane libera, valvata vel perobscure imbricata, haud unguiculata, late vel rarius angustius elliptica vel rarissime obovata, apice rotundata, ad marginem papillulosa vel ciliata, sæpius punctatim vel lineatim picta. Antheræ optime sessiles petalisque paullo minores his per anthesin recurvis vel patentibus porrectæ, birimose tota longitudine introrsum dehiscentes, apice sueto acuminulo obtusiusculo papilloso auctæ, dorsifixæ et sæpius ± alte petalis connatæ rarius liberæ. Ovarium ovoideum, glabrum; stylo nullo vel brevissimo raro manifesto; stigmate capitato sæpius morchelliformi. Placenta uniseriatim perpauci(2–4)-ovulata. Fructus (non nisi specierum sandivicensium cognitus) globosus, 1-spermus, apice mucronulatus; endocarpio crustaceo. Semen globosum, placentæ rudimentis indutum, basi intrusum; albumine corneo, lævi; embryone cylindraceo, transverso. Fruticuli nunc nani habitu myrtillaceo nunc alti vel arbores foliio sparsis, integerrimis. Inflorescentiæ laterales, e foliorum delapsorum vel vigentium axillis provenientes, umbellatæ, sæpius perpaucifloræ, e ramulis brevissimis verruciformibus vel abbreviate cylindricis squamuligeris formatæ. Flores parvi, pedicellati.

Genus Rapaneas includit dialypetalas.

Conspectus Subgenerum.

A. Flores 4-meri; folia nervo marginali omnino destituta. Species novo-zelandicæ. Subgenus I. Eusuttonia, Mez.

B. Flores 5-meri; folia nervo marginale nunc permanifesto nunc obscuro prædita. Omnes insularum Sandwich incolæ. Subgenus II. Rapaneopsis, Mez.

Rapanea, Aubl.

Rapanea, Aubl. Hist. pl. Guiane franç i. (1775) 121, t. 46; Juss. Gen. (1789) 288; Mez in Urb. Symb. antill. ii. (1901) 427. Duhamelia, Domb. (non Pers.) ap. Lam. Enc. i. (1783) 245. Manglilla, Juss. Gen. (1789) 151; Rœm et Schult. Syst. iv. (1819) p. xlvi. et 504. Caballeria, Ruiz et Pav. Prodr. (1794) 41; Willd. Spec. pl. iv. (1805) 1118. Rœmeria, Thunb. (non alior.) Nov. gen. ix. (1798) 130 et in Römer Arch. ii. 5 et Prodr. pl. capens. ii. (1800) 184 et Fl. capens. ii. 67 (*e. p.*). Athrophyllum,

Lour. Fl. chochinch. i. (1790) 120 et ed. Willd. 148. Scleroxylum, Willd. in Berl. Magaz. iii. (1809) 57 et Enum. pl. hort. berol. (1809) 249. Merista, Banks and Sol. ex A. DC. Prodr. viii. (1844) 95. Suttonia, A. Rich. (non Hook. f.) Voy. Astrol. Bot. (1832) 349; Lindl. Veg. Kingd. (1847) 648. (?) Plotia, Adans. Fam. ii. (1763) 226. Myrsine, R. Br. Prodr. i. (1810) 533 et sequentium omnium pro maxima parte, nempe; H. B. K. Nov. gen. et Spec. iii. (1818) 248; A. DC. in Trans. Linn. Soc. xvii. (1834) 104 et in Ann. Sc. Nat. 2 sér. ii. (1834) 292 et xvi. (1841) 78 et in DC. Prodr. viii. (1844) 92; Lindl. Veg. Kingd. (1847) 648; Miq. in Fl. brasil. x. (1856) 306 et Fl. Ind. bat. ii. (1856) 1014; Scheff. Comm. Myrs. Archip. Ind. (1867) 46; Hook. f. in Benth. and Hook. f. Gen. ii. (1876) 642; Clarke in Hook. f. Fl. Brit. India iii. (1882) 511; Pax in Engl. and Prantl. Pflzfam. iv. 1 (1889) 92; Baill. Hist. pl. xi. (1892) 333.

Flores hermaphroditi vel sæpissime reductione sexus alterius dioici, 4-vel 5- (raro numeris auctis 6–7-) meri. Sepala parva, nunc fere libera nunc basi $\pm$ alte sed rarissime ultra $\frac{1}{3}$ longit. connata, imbricata valvatave, ovata vel triangularia semper symmetrica, margine sueto ciliolata, sæpissime punctis vel lineis glandulosis picta. Petala varie connata nunc infime brevissime coalita, nunc sæpius usque ad $\frac{1}{3}$ connata nunc raro a medio libera, in speciebus perpaucis usque at $\frac{4}{5}$ longit. coalita, lobis ovatis vel ellipticis per anthesin patentibus vel recurvis vel rarissime erectis, sueto lineatis vel punctatis, margine saltem sæpissime papillosis. Stamina corollæ fauci inserta filamentis omnino nullis, antheris ipsis sæpissime dorso cum petalis aliquid connatis, introrsum tota longitudine birimose dehiscentibus, apice sueto acuminulatis et hic sæpius papillulosis, ovatis vel ellipticis brevibus. Ovarium globosum vel ellipsoideum stylo in floribus ♀ constanter nullo; stigmate sessile florum ♂ varie irregulariter formato, florum ♀ secundum areas geographicas (vix tamen subgenerice efferendas) regulariter formato: asiaticis omnibus elongato farciminiformi stylum mentiente; africanis scutato margine (sæpius loboso) deflexo fungiforme; australiensibus polynesiacisque plurimis capitato indiviso; americanis conico sueto morchelliformi vel regulariter in lobos erectos diviso. Placenta uniseriatim pauciovulata. Fructus pisiformis, siccus vel carnosus, 1-spermus, endocarpio crustaceo vel coriaceo vel lignoso. Semen globosum, læve, basi intrusum; albumine corneo haud vel raro paullo ruminato. Embryo elongatus, transversus, sæpius curvatus. Arbores vel frutices glabri vel pubescentes foliis sæpius $\pm$ manifeste lepidotulis. Folia integerrima vel rarissime (tunc sæpius spinose) dentata. Flores parvi, e ramulis quam

maxime abbreviatis nunc deciduis minutissimis sæpius vix reperiendis nunc perennantibus crasse cylindricis vel verrucosis umbellatim (vel in speciebus perpaucis perabbreviate racemose) provenientes, bracteolati.

New Zealand Species of Myrsinaceæ.

1. Suttonia chathamica (F. Muell.), Mez. *Myrsine chathamica*, F. Muell! Veg. Chatham Isl. (1864) 38.
2. Suttonia novo-zelandensis (Colenso), Mez. *Myrsine neo-zelandensis*, Colenso! in Trans. New Zealand Inst. xxii. (1890) 479.
3. Suttonia montana, Hook f.! Fl. Nov. Zeland. ii. (1855) 334. *Myrsine montana*, Hook. f.! Handb. New Zealand Fl. (1867) 184.
4. Suttonia divaricata (A. Cunn.), Hook. f.! Fl. Antarct. (1844–47) 51, t. 34, et Fl. Nov. Zeland. ii. (1853–55) 4. *Myrsine divaricata*, A. Cunn.! in Ann. Nat. Hist. 1, ser. ii. (1839) 47; Hook. f.! Handb. New Zealand Fl. (1867) 184. *Myrsine pendula*, Colenso! in Trans. New Zealand Inst. xxi. (1889) 94.
5. Suttonia nummularia, Hook. f.! Fl. Nov. Zeland. (1853–55) 173. *Myrsine nummularia*, Hook. f.! Handb. New Zealand Fl. (1867) 184.
6. Suttonia coxii, Cockayne.* *Myrsine coxii*, Cockayne in Trans. New Zealand Inst. xxxiv. (1902) 318.
7. Rapanea salicina (Heward), Mez. *Myrsine salicina*, Heward! in Hook. London Journ. Bot. i. (1842) 283 in nota; Hook. f., Handb. New Zealand Fl. (1867) 184. *Suttonia salicina*, Hook. f.! Fl. Antarc. (1844–47) 52 et Fl. Nov. Zeland. ii. (1855) 172. *Suttonia saligna*, Walp. Rep. vi. (1847) 450 (Sphalm.).
8. Rapanea kermadecensis (Cheeseman), Mez. *Myrsine kermadecensis*, Cheeseman! in Trans. New Zealand Inst. xxiv. (1892) 410.
9. Rapanea urvillei (A. DC.), Mez. *Myrsine urvillei*, A. DC.! in Trans. Linn. Soc. xvii. (1834) 105 et in DC. Prodr. viii. (1844) 95; A. Cunn. in Ann. Nat. Hist. (1839) 47; Hook. f. Handb. New Zeal. Fl. (1867) 184. *Merista lævigata*, Banks et Sol.! ap. A. Cunn. *l.c.* (sed specimen alterum hoc nomine in Herb. Banks! signatum ad Rubiaceas translocandum!). *Suttonia australis*, A. Rich! Ess. Fl. Nouv. Zél. (1832) 349, t. 38. *Myrsine richardiana*, Endl. in Ann. Wien Mus. i. (1838) 171. *Myrsine undulata*, A. Cunn. in Ann. Nat. Hist. 1, ser. ii. (1839) 47.

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* It will be seen that I have made use of this opportunity to place the Chatham Island species, originally referred by me to *Myrsine*, in the genus *Suttonia*, in accordance with the views of Mez.

Art. XLIII.—*The Stem-structure of some Leafless Plants of New Zealand, with Especial Reference to their Assimilatory Tissue.*

By Miss A. C. Finlayson, M.A.

Communicated by Dr. Chilton.

[*Read before the Philosophical Institute of Canterbury, 3rd September, 1902.*]

Plates XLV.–XLVII.

The plants whose stems were selected for investigation were *Discaria toumatou*, *Clematis afoliata*, and three species of *Carmichaelia* (*C. flagelliformis*, *C. monroi*, and *C. nana*). All are natives of New Zealand. They form a descending series with regard to their leaf-formation. *Discaria toumatou* has small leaves in spring, which are not, however, adequate for the work of assimilation; in *Clematis afoliata* the leaves are represented only by the long petioles; while in *Carmichaelia flagelliformis* there are practically no available leaves, only a few very minute leaves being developed at the same time as the inflorescences in spring; in *C. nana* and *C. monroi* there are no leaves at all in the adult plant. They are all included by Diels in his book, "Vegetations-Biologie von Neu-Seeland" (arbeit aus dem Königl. botan. Museum zu Berlin, Leipszig, 1896), as pasture-land plants, found only in the east and south-east. *Clematis* and *Carmichaelia* are derivatives of the forest flora (p. 246). All except *Clematis afoliata*, which is herbaceous and can climb by means of its petioles, are shrubs (which may reach even the height of trees in the case of *Discaria toumatou* in favourable localities). *Carmichaelia flagelliformis* is a rather straggling shrub, which partly lies on the ground and partly grows erect, and is much branched; *C. monroi* and *C. nana* are very dwarfy rigid shrubs, growing close to the ground. Of the two, *C. nana* is much the smaller. *Discaria toumatou* in exposed situations only reaches the height of a bush, with a very prickly and straggling appearance. All are characterized by their xerophytic structure. To quote Diels (p. 246): "Their xerophytic structure is of striking intensity and difficult to understand in comparison with other floras, if we recollect that even the driest areas of New Zealand suffer under a less excessive climate and less frequent droughts than middle Europe. Yet the diminution of transpiration is not less in these bushes than in the plants of dry steppes; and habitually the many species, so widely separated, systematically converge in an extraordinary manner and agree in physiognomy with desert vegetation."

Discaria toumatou, Raoul.

This plant belongs to the order *Rhamnaceæ*. According to Hooker,* its habitat is "east coast and interior of the southern part of the North and throughout the South Island" (p. 44). He describes it as "a thorny bush in dry places, becoming a small tree in damper localities, with spreading branches, and branchlets reduced to spines 1 in.–2 in. long. The leaves are small, being $\frac{1}{2}$ in.–$\frac{2}{5}$ in. in length, fascicled in the axils of the spines, and absent in old plants." This plant can hardly be described as leafless; it forms a connecting-link between the plants with abundant leaves and those which are quite leafless.

The spines borne on the smaller branches are really modified shoots; they arise decussately in the axils of minute scales; the length of the branch between each pair of spines is about 1 in. (fig. 1). They occur with great regularity as a rule, but in favourable situations they may be almost entirely suppressed, and are then represented only by aborted bud-shoots appearing as little warts on surface of the stem. In spring, below each spine arise three or four leaves, together with three or four small sessile flowers; these arise not from the spine, but from the stem immediately below the spine. No bud of leaves covers the branch-termination. Both spines and younger stems are green.

Leaf-structure.

The leaf is of the ordinary dorsiventral type (figs. 1*b*, 1*c*). In the centre is the midrib with lateral veins. On the upper surface is an uninterrupted layer of large epidermal cells, appearing squarish in transverse section, with a very thin cuticular layer on the outside wall. Underneath are about three layers of small-celled closely packed palisade cells, which pass over into the more spongy tissue of the lower surface. A single epidermal layer, whose cells are rather smaller than those of the epidermis of the upper surface, with numerous stomata (figs. 2*a*, 2*b*, 2*c*) whose opening is best seen in a longitudinal section of the leaf (fig. 2*c*), bounds the under-surface of the leaf. Its outer walls are also slightly cuticularised.

In the centre of the leaf is the midrib, with xylem above and phloem below. Between the phloem and the lower epidermis are transparent protoplasmic rounded cells, which probably contain water. There are no hairs present on upper or lower surface.

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* "Handbook of the New Zealand Flora," by J. D. Hooker. London: Reeve and Co., Covent Garden, 1867.

Stem and Spine Structure.

The spine closely resembles the stem in internal structure, the only difference being that in the former the pith-cells become disorganized, thus leaving a hollow up the centre of the spine, while in the stem they persist as large polygonal cells. The spine ends in a sharp point. Both spine and stem are quite glabrous.

In transverse section (fig. 3*a*) the stem is not circular, but rather elliptical. On the outside is the epidermis, with a thick external cuticle interrupted at intervals by the slightly depressed stomata, which are best seen in a longitudinal section, as the opening of their guard-cells is at right angles to the longitudinal organic axis (figs. 3*b*, 3*c*). The cells of the epidermis are longish in transverse section. Underneath is a single layer of rather large polygonal cells, slightly elongated transversely. These are thin-walled and contain very granular protoplasm, and are interrupted only underneath the stomata (*st.* cells).

The epidermis may be considered as 2-layered, this layer being the lower one. Probably its function is to store water. Beneath it lies the chlorenchyma (*p. t.*), composed of three or four layers of closely packed palisade cells containing chlorophyll granules. These cells are small, polygonal, and elongated in the radial direction of the stem. Just below the palisade tissue are two or three layers of granular, large, polygonal cells, similar to those of the subepidermal layer. This tissue together with the chlorenchyma and epidermis occupy one-third of the thickness of the radius of the stem; the vascular tissue, which is immediately interior, occupies almost one-half, and the central pith fills up the remainder.

Vascular Tissue.

In the stem of *Discaria toumatou* no special stereom tissue is present which might serve to keep the stem rigid; hence this function has to be performed by the vascular tissue, especially by bast fibres and xylem cells. The vascular bundles form a compact ring round the pith; the medullary rays consist each of a single row of small protoplasm-containing cells, elongated in direction of radius of stem and polygonal.

On the outside of the vascular bundles are groups of very thick-walled prosenchymatous cells without protoplasm. These are the bast fibres; they are not arranged very regularly; in longitudinal section they are spindle-shaped, tapering at both ends and fitting into each other. In transverse section, they are ovoid, with a very small opening in the centre (figs. 3*b*, 3*c*, *b.f.*). The rest of the phloem

tissue is composed of granular phloem parenchyma (fig. 3*c*, *p. par.*), whose cells appear roundish in transverse section, and a few sieve-tubes with transverse plates (fig. 3*c*, *s. t.*). There is a well-developed cambium of 4–5 layers of small, squarish, transversely elongated cells containing conspicuous nuclei.

The xylem forms more than half the thickness of the entire vascular bundle. There are but few true vessels, one or two spiral and one or two pitted, in each bundle; the greater part of the xylem tissue is composed of libriform cells. In transverse section these appear as polygonal cells with very thick walls, and fitting closely into each other. In a longitudinal radial section (fig. 3*c*) they are seen to consist of greatly elongated cells, with oblique end walls which dovetail into each other. The thickened cell-walls have thin spots both on longitudinal and transverse walls by which they can communicate with each other. The true vessels occur in the inner part of the vascular xylem.

The pith-cells, which occupy the centre of the stem, are smaller on the outside (next to the xylem) and larger in the centre of the stem. They are polygonal, thin-walled, about as long as they are broad; those next to the xylem contain a great many starch-grains (in winter), while those in the centre have only a few starch-grains.

The older stems and spines become dry and scaly; only the younger can assimilate. The most remarkable features about the structure of the stem are the double epidermis, the great development of chlorenchyma and of woody cells, and at the same time the small number of true vessels in the wood. The two former are evidently intimately concerned with the work of assimilation, and the latter with the question of rigidity. The abundant palisade chlorenchyma facilitates assimilation, while the libriform cells give the stem the rigidity and at the same time the elasticity so necessary to a plant which is often exposed to wind.

Clematis afoliata, Buchanan.

Hooker does not mention this species in the "Handbook of New Zealand Flora," but T. Kirk, in the "Students' Flora of New Zealand," mentions it on p. 3. He says its habitat is "Middle Island: Nelson, Marlborough, Canterbury, and Otago; but local." It belongs to the order *Ranunculaceæ*. In other species of the same genus the leaves have a long petiole; in this species only the petiole is present—at least, in the adult plant. The petioles arise in pairs from a node, each pair being at right angles to the pair above it; the internodes are very long (about 7 in. in older shoots). The young shoot arises in the axil of the petiole, with the inflorescence at its

base. The length of a fully grown petiole is about 4 in. (fig. 4).

The stem is fairly slender, finely striated longitudinally; when young it is very soft and flexible; later it becomes firmer, but retains its suppleness. The petioles may act as tendrils as well as assimilatory organs.

Internal Structure of the Stem.

This stem bears a stronger resemblance to the ordinary dicotyledonous type of stem than does *Discaria toumatou*. In the centre is the pith of large thin-walled cells, surrounded by a ring of vascular bundles with medullary rays between them. The fundamental tissue shows most deviation; it is differentiated into chlorenchyma and mechanical supporting tissue, which alternate round the stem. The outline of the stem (in transverse section) is wavy, with alternating ridges and depressions; the ridges occur above the stereom bands, the chlorenchyma occurring just underneath the depressions (hence the longitudinally striated appearance of the stem). There is a similar arrangement of the tissues seen also in the petiole, hence only the stem-structure is described.

Stem.

On the outside of the stem is a 2-layered epidermis (figs. 5*a*, 5*b*, 5*c*). The cells of the outer layer are larger than those of the inner layer, which also differ in being slightly elongated in a direction at right angles to the radial direction. The cells of the outer layer are slightly elongated in the radial direction; on their outer walls is a firm but not very thick cuticle. Stomata only occur in the depressions of the stem (figs. 5*a*, 5*b*).

The chlorenchyma cells are large, with air-spaces between them. They have their longitudinal axis parallel to stem-radius. They are irregular in shape, with chlorophyll granules arranged chiefly on their side walls.

Immediately under a chlorophyll strand, in a radial direction towards centre of stem, comes a medullary ray. The cells of the medullary ray are slightly elongated, and contain starch. In transverse section they appear polygonal from mutual pressure (fig. 5*b*, *m. r.*). There is no formation of interfascicular cambium.

The pith is very well developed in this stem, occupying about one-third of the stem-radius. It is composed of thin-walled cells, larger towards the centre of the stem; rounded in transverse section, slightly elongated in longitudinal section (fig. 5*c*).

The mechanical supporting tissue in the young stem is composed of thin-walled living-cells tightly packed together,

and polygonal in transverse section. Its cells are smaller than those of the chlorophyll-containing tissue which lies on either side of it. As the stem grows older its cell-walls become much thickened, and the protoplasmic contents disappear. If a transverse section of the stem (mounted in water) be treated with chlor-zinc-iodine, the walls of the mechanical tissue, as well as those of the cuticularised outer epidermal wall, are stained yellow, those of the wood-tissue being stained a deeper brown. So it is probable that the thickening of the cells of the mechanical tissue is of a similar nature to cutin. The cells of this tissue are elongated, with oblique transverse walls (fig. *5d, m. st.*).

Immediately below each strand of mechanical tissue is a vascular bundle. Between the thickened elongated cells of the mechanical strand and the phloem of the vascular bundle are a few parenchyma cells (figs. *5b, par. c.; 5d, par. c.*).

The vascular bundle is open, consisting of phloem, cambium, and xylem. It forms but a small proportion of the total stem-radius, and is not modified specially to perform a mechanical function as in the stem of *Discaria toumatou.*

The phloem consists of phloem parenchyma, sieve-tubes, (fig. *5d, s. t.*), with a few bast fibres consisting of long, narrow, thick-walled cells (fig. *5d, b. f.*) occurring on outside of the phloem tissue.

The xylem elements include a few spiral vessels (fig. *5d, sp. v.*). I also saw an annular vessel (fig. *5d, a. v.*) on the inside, a few pitted vessels (fig. *5d, p. v.*) towards outside of the xylem, and a few woody cells, elongated, with oblique transverse walls; thickened parts alternate with thin spaces on both longitudinal and transverse walls (fig. *5d, w. l.*). Between the xylem and phloem are a few cambium cells, with the ordinary conspicuous nuclei and thin cell-walls.

The stem of *Clematis afoliata,* like that of *Discaria toumatou,* is entirely wanting in hairs. A certain amount of protection against excessive transpiration is afforded by the cuticle of the epidermis, and by the fact that the stomata occur only in the depressions of the stem; at the same time the air-spaces of the chlorenchyma allow abundant aeration, so that the chlorenchyma can carry out the work of assimilation satisfactorily. The mechanical tissue is able to keep the stem sufficiently stiff, so that no special development of the vascular tissue is necessary.

Carmichaelia.

Three species of *Carmichaelia* (*C. flagelliformis, C. monroi,* and *C. nana*) remain to be considered.

This genus belongs to the order *Leguminosæ*. Hooker* says, "This genus is confined to New Zealand, and is composed of shrubs or small trees, usually quite leafless, or leafy in the young state only. The branches are flattened and green." Diels† says concerning this genus, "*Carmichaelia exsul*, with many tender leaves, grows in the underwood of the palm forests of Lord Howe Island; and even *Carmichaelia australis*, the only representative of its stock in the north-west of New Zealand, still parades in a rich foliage. . . . In their growth they certainly all bear pinnate leaves, like the phyllode-bearing *Acacias* of New Zealand. These leaves, in the neighbourhood of the soil protected by the shade of higher growths and by a hairy covering from drying up, possess anthocyanin in their interior and insunk stomata. From the beginning stem and leaf-stalk are provided with chlorenchyma and stereom, so that when they have attained a height of 5 cm. the little plants already stop leaf-formation and transfer the function of the leaves to flat shoots which now serve for nourishment for several years." I had no opportunity of examining young plants. All three species agree in the flattened arrangement of their shoots, but differ somewhat in habit.

Carmichaelia flagelliformis, Colenso.‡

This is a shrub about 2 ft.–4 ft. in height, much branched with rather slender branchlets (fig. 6*a*); often it straggles on the ground. A few very small leaves appear on the young branches (not on the older ones), with the inflorescences; these are only $\frac{1}{10}$ in. in length (October), and hence are not of much practical use as assimilatory organs (fig. 6*b*). The leaves are of the ordinary dorsiventral type; they have a few hairs on their upper and lower surfaces, the stomata are borne on the lower surface, and there is a violet colouration (anthocyanin) in some of the subepidermal cells of the lower surface. The shoots arise at an acute angle from the branch which bears them, and their flattened surfaces are not horizontal, but vertical; so the sun's rays do not strike them directly, evaporation being lessened by this means. A similar growth of shoot-axes is seen also in *Carmichaelia monroi* (fig. 8) and *C. nana* (not represented).

The flattened shoot of *C. flagelliformis* is about $\frac{1}{12}$ in. broad; in *C. monroi* it is about $\frac{1}{8}$ in. broad, and is slightly stouter; in *C. nana* it is very slender, the flattened surface being about $\frac{1}{8}$ in. broad.

* "Handbook of New Zealand Flora."

† "Vegetations-Biologie."

‡ Hab. North and South Islands: East Coast, Milford Sound, Nelson, Otago, Akaroa.

Stem-structure.—On the outside is a double-layered epidermis, with slightly insunk stomata. There is a thick cuticle outside. The cells of the outer epidermal layer are larger than those of the inner layer, and are somewhat different in shape, those of the outer layer being squarish, while those of the inner layer are somewhat elongated in a direction at right angles to the radial one (fig. 7*a*). The lower epidermal layer is wanting immediately under the stomata.

Immediately below the epidermis is a ring of chlorenchyma tissue extending right round the stem. This ring is not complete, but is interrupted by the strands of mechanical tissue, which occur in large numbers immediately below the epidermis. So the chlorenchyma and stereom alternate round the stem. Each of the stereom groups is small, and does not extend inwards as far as the vascular bundles. The cells are small, thick-walled, elongated, polygonal in transverse section (fig. 7*a*, *m. st.*). Each group is surrounded (except on the side which is adjacent to the epidermis) by a layer of thin-walled colourless polygonal cells which separate the mechanical tissue from the chlorenchyma. Small groups of stereom cells, surrounded by a layer of thin-walled cells, also occur in the chlorenchyma; these groups alternate with the subepidermal ones. There are also a few stereom cells on the outside and inside of each vascular bundle, but in this case there is no layer of thin-walled cells accompanying them. The chlorenchyma cells are larger than those of the stereom tissue. They extend inwards as far as the ring of vascular bundles. The stomata occur only above the chlorophyll tissue in the epidermis. The outer chlorophyll-containing cells are elongated in the radial direction, and have the form of palisade tissue; further inwards they are more irregular in shape, with fewer granules and air-spaces between them.

The vascular bundles are arranged in an oblong ring round the central pith, with medullary rays between them. They are composed of phloem, cambium, and xylem. As the stem grows older, thickening takes place; the originally flat organ is rounded off, so the assimilatory tissue is not interfered with. A great part of the xylem thickening consists of libriform cells (fig. 7*c*, *l. t.*); these are able to support the stem, so the stereom tissue becomes less necessary.

The cells of the pith are large and polygonal; those of the medullary rays are elongated radially to a slight extent.

Anthocyanin is developed in the epidermal tissue of the edges of the shoot, but not of the flattened sides; probably this may be explained by the fact that owing to the habit of the plant only the edges receive the sun's rays directly.

C. monroi, Hooker,* and **C. nana,** Colenso.†

Both of these differ in habit from *C. flagelliformis*. Their growth resembles that of alpine plants. *C. nana* is a "very dwarfy, glabrous, rigid shrub, 2 in.–4 in. high, with much-compressed minutely striated branchlets $\frac{1}{12}$ in. – $\frac{1}{8}$ in. in diameter" (Hooker). *C. monroi* grows higher, reaching about 1 ft. in height, but much more closely, forming a very firm cushion of circular form, in which, however, the individual branches and branchlets are easily separated and distinguished. In neither is there any sign of leaves in the adult form, and they flower later than *Carmichaelia flagelliformis*. The tips of the shoots in *C. monroi* are coloured brownish-red.

Stem-structure.—In general stem-structure they resemble *C. flagelliformis*, but the chlorophyll tissue is developed in greater abundance in proportion to the stereom tissue than in the latter. There is the same double-layered epidermis with thick external cuticle; in *C. monroi* there are slight ridges above the stereom strands, while the stomata occur in the depressions, underneath which is the chlorophyll tissue. Underneath each stoma is an air-cavity. The chlorenchyma tissue extends inwards as far as the vascular bundles, and is of palisade type in both *C. monroi* and *C. nana*, without any air-spaces even in the inner layers. (Compare *C. flagelliformis*, where air-spaces are present.)

In *C. monroi* the stereom tissue may or may not extend inwards as far as the vascular bundle (fig. 9); when it does not there are occasional small isolated groups alternating with the peripheral groups, and occurring in the chlorophyll tissue. Both these groups have a layer of polygonal thin-walled cells around them. Where the stereom tissue does not extend as far as the vascular bundle there is a crescent-shaped group of stereom cells on the outside of the phloem, with a half-circle of thin-walled cells round the outside; there are also a few similar thick-walled cells on the inside of the xylem, but with no special thin-walled cells round them. The pith is composed of large polygonal cells fitting together, without intercellular spaces. The medullary-ray cells are similar in shape, but somewhat smaller; they pass over gradually into the chlorenchyma cells. The stereom cells are polygonal, tightly packed together; when the shoot is quite young, as also in *C. flagelliformis*, the cell-walls are quite thin, and the stem is then very soft; but it soon loses its softness and becomes firm owing to the thickening of the cell-walls.

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* Hab. South Island.

† Hab. North Island: Dry mountainous country at base of Mount Tongariro. South Island: Southern Alps; Otago, Waitaki River.

In *C. nana* the stem is much thinner. There are not so many vascular bundles as in the stem of *C. monroi*, nor are they opposite each other. The stereom strands reach to the vascular bundle, surrounded on outside by the thin-walled polygonal layer of cells seen also in *C. monroi* and *C. flagelliformis*. The cuticle is not quite so thick as in *C. monroi*; the stomata occur in a similar place (above chlorenchyma in the epidermis). The chlorenchyma is palisade, but there are occasional air-cavities (fig. 10*b*). A few isolated groups of thick-walled cells, with a surrounding ring of thin-walled cells, occur in the chlorenchyma tissue, but these are of minor importance owing to their small size. On the inside of the xylem occurs a group of stereom cells; there may be only a few (as in vascular bundle on right hand of fig. 10*b*), or more (as in vascular bundle on left-hand side of the same figure). The pith-cells are large and polygonal. Since the tissues composing the stems of the three species are similar, a longitudinal section of the stem of *C. nana* only is given (fig. 10*b*). The stereom cells are seen to be somewhat elongated with oblique transverse walls, all the walls being much thickened. (The thin-walled layer of cells is not represented.) The phloem elements include sieve-tubes and phloem parenchyma (fig. 10*b*, *s. t.*, *p. par.*), with cambium (*cm.*) on inside. Xylem elements include spiral vessels (*sp. v.*), pitted vessels (*p. v.*), with elongated woody cells between. Inside of the xylem is the stereom tissue, followed by the pith, and on the other side chlorenchyma with epidermis. The opening of the stoma is seen best in longitudinal section. The stomata of all three species are fairly numerous, not very large, with no peculiar structure, and only very little insunk (figs. 10*b* and 7*b*).

At the apex of the shoot of *C. monroi* a violet-coloured fluid (anthocyanin) is present in the inner epidermal cells; lower down in the stem it is absent; it is also absent in *C. nana*.

The stems of all three species are glabrous.

In the five species which have been considered, evidently the chief danger to be guarded against is excessive transpiration. The total absence of hairs (except in the minute leaf of *C. flagelliformis*) so commonly occurring in alpine plants shows that it is not a question of loss of heat, but rather of avoidance of excessive heat. This is effected in the case of the *Carmichaelias* by the vertical position of the shoot-axis, and probably in *C. monroi* by the development of anthocyanin in the shoot-apices (the lower parts being protected by the cushion-like form of the plant). Transpiration is checked chiefly by the thick cuticle found in all of them, and

is also aided by the occurrence of the stomata in slight depressions, and by the rigidity of the shoot-axes, which are therefore less easily shaken by the wind, and at the same time are possessed of sufficient elasticity to be able to avoid danger of breaking in a high wind. The conditions to which they are exposed on the open plains of the south and south-east of New Zealand are considerable heat, a considerable degree of dryness (especially in summer, when the dry, hot nor'-westers are blowing), and strong winds.

The conditions of climate prevailing at the present day do not seem to be sufficient to account for their extreme xerophytic structure. *Clematis afoliata* and *Carmichaelia* are derivatives of the forest flora. Probably they acquired their characteristic structure in the days of "Great New Zealand," when the Southern Alps were higher, and therefore the eastern plains were drier and subject to more excessive heat. "The forest flora which could not adapt itself to the climate perished or retreated to more rainy parts" (Diels).

In *C. afoliata* and the *Carmichaelias* the necessary rigidity is attained by means of development of stereom tissue in the cortex; in *Discaria toumatou* by means of the abundant development of the woody cells of the xylem, and also to a less extent by the bast fibres. In all there is a double epidermis layer; perhaps the inner layer may be of use to a slight extent as water-storing tissue. Stomata are only developed above the chlorenchyma, where they are of use. The thin-walled cells round the stereom groups are probably also of use in this respect—*i.e.*, for water-storage.

The development of mechanical tissue must not interfere with the assimilatory chlorenchyma. In the words of Diels (*l.c.*, p. 248): "Everywhere is typical palisade tissue effective for assimilation, which is indeed very comprehensible from the physical environment, and the great demands which the total absence of foliage makes from the tissue which represents it. In its centrifugal tendency the chlorenchyma tissue comes into conflict with the not less important supporting tissue. The various solutions of this problem determine the histological structure of the stem." Palisade chlorenchyma occurs in all the species which have been considered. In *Discaria toumatou* it extends in an uninterrupted ring round the stem, so that it is able easily to perform the work of assimilation. In the other plants it extends inwards as far as the vascular bundles, and hence the products of assimilation can be transferred to the sieve-tubes, and the ascending sap is also able to reach the chlorophyll tissue.

EXPLANATION OF PLATES XLV.–XLVII.

Fig. 1.

(*a.*) One of younger shoots of *Discaria toumatou*, with leaves below thorns.

(*b.*), (*c.*) Leaves of same.

All three life size.

Fig. 2.

(*a.*) Transverse section of leaf of *Discaria toumatou*; enlarged.

ep. Epidermis.
p. t. Palisade tissue.
xy. Xylem.
ph. Phloem.

(*b.*) Surface section of under epidermis of leaf showing stomata; enlarged.

(*c.*) Opening of a stoma with two guard-cells; enlarged.

Fig. 3.

(*a.*) Transverse section of half of stem of *D. toumatou*; enlarged.

st. Stoma.
cut. Cuticle.
e. Epidermis.
i. e. Inner epidermis.
b. f. Bast fibres, *s. t.* Sieve-tube, *p. par.* Phloem parenchyma } phloem.
p. t. Palisade chlorenchyma.
g. p. Ground parenchyma.
cm. Cambium.
w. c. Libriform cells, *p. v.* Pitted vessel } xylem.
m. r. Medullary ray.

In centre pith with *st. gr.* (starch-grains).

(*b.*) Surface section of stem of *D. toumatou* with stomata; enlarged.

(*c.*) Longitudinal section (half of stem) of *D. toumatou*; enlarged. Same lettering as in (*a*). Medullary rays may be seen in xylem.

Fig. 4.

Part of stem of *Clematis afoliata*, with petioles of leaves (*p.*) and new shoots arising in their axils; life size.

Fig. 5.

(*a.*) Surface section of stem of *C. afoliata*, showing epidermis with alternating strips, one devoid of and one bearing stomata.

(*b.*) Transverse section of part (quarter) of stem of *C. afoliata.*

st. Stoma.
cut. Cuticle.
e. Epidermis.
i. e. Inner epidermis.
ph. Phloem.
cm. Cambium.
xy. Xylem.
m. st. Mechanical stereom.
chl. Chlorenchyma.
par. Parenchyma.
m. r. Medullary-ray pith.

(*c.*) Longitudinal radial section through chlorenchyma pith. Does not pass through the vascular bundle.

(*d.*) Longitudinal radial section through stereom vascular bundle and pith. Same lettering as (*b*); also,—

b. f. Bast fibres, *s. t.* Sieve-tube } phlo
p. v. Pitted vessel, *w. c.* Woody cells, *sp. v.* Spiral vessel, *a. v.* Annular vessel } xylem.

Fig. 6.

(*a.*) Young shoot of *Carmichaelia flagelliformis*, with inflorescences (*inf.*).

(*b.*) Leaf of *C. flagelliformis.*

Both life size.

Fig. 7.

(*a.*) Tranverse section of half of stem of *C. flagelliformis*. All the cells are filled in, in order to show more clearly the arrangement of the tissues.

ep. Epidermis. *thin w. c.* Thin-walled cells.
chl. Chlorenchyma. *m. st.* Mech. stereom.

(*b.*) Surface section of epidermis of stem, with alternating strips containing stomata, and devoid of them.

(*c.*) Transverse section of part of stem of *C. flagelliformis*, inclu ding one vascular bundle. To show thickening by formation of libriform tissue (*l. t.*).

Fig. 8.

Shoot of *C. monroi;* life size. Transverse scars are scales.

Fig. 9.

Lettering same as in 7 (*a*). In upper half of the section the vacant spaces represent mechanical stereom which has not been filled in, in order to show more clearly the structure. In lower half of the section the chlorophyll granules have been omitted for the same reason.

Fig. 10.

(*a.*) Transverse section of stem of *C. nana*. Same lettering as in 7 (*a*); *air c.* = air-cavity.

(*b.*) Longitudinal section as through dotted line 1 to 2 in 10 (*a*). Same lettering as in 7 (*a*); also,—

s. t. Sieve-tube
cm. Cambium
p. v. Pitted vessel } Vasc. bundle.
w. c. Woody cell
sp. v. Spiral vessel

Note.—The sections of different stems are not drawn to a strictly proportional scale of size.

Art. XLIV.—*Note on Hybrid Ferns.*

By H. C. Field.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

About three weeks ago Miss E. Creswell, of Te Horo, sent me a specimen of a fern which she could not class, and which she wished me to name for her. It was like *Hymenophyllum demissum*, but she said it had stellated tomentum on the stipes, rachis, and costæ. Except that it had those parts less glossy than usual, and was of a darker colour than ordinary (probably from having been grown in deep shade), I could see

nothing to distinguish it from *H. demissum*, even with a powerful magnifying-glass, and wrote to her to that effect. She has since sent me better specimens, and with them some which she had rightly classed as *H. demissum*, but which had evidently grown pendulous on a tree-trunk, and were of a paler green and more transparent texture than usual. As some members of our Society are no doubt aware, I was blind with cataract for about three years; and though by an operation the sight of one eye is so far restored that I can read and write, yet telescopes and microscopes are useless to me, not being capable of being adjusted to suit my altered vision. Thus, though the second specimens were less glossy than the first, I could not detect distinct tomentum. My son, however, happened to come to see me, and I showed him the specimens, which he said had the framework of the ferns distinctly furry; and thus I have come to the conclusion that the fern is a hybrid, though not sufficiently distinct from *H. demissum* to justify being separately classed.

It is not the first time that I have had ferns of a similar character sent to me by collectors for the purpose of being named; and I have also met with such examples myself. In particular, in a little bush at Otaihanga I found what was clearly *Nephridium glabellum*, yet which had developed slightly creeping roots like *N. decompositum;* and near to Nelson there is a small form of *Asplenium umbrosum* which creeps slightly instead of merely forming a crown of fronds. The late Rev. W. Colenso also evidently met with similar cases, and classed them as new ferns—*e.g.*, his *Lomaria aggregata* is merely *L. lanceolata*, which had developed lateral crowns; and, curiously enough, just at the time when his paper on it was published in the Transactions, I noticed that a plant of this fern in one of my cases had similarly divided into several crowns. It seems to me pretty evident that when two prothalli grow so close together that when their edges meet they are forced upwards, their sexual organs must come close together; and if they are of closely allied species hybridisation is likely to occur. Thus I think the fern of which Miss Creswell sent me specimens is a cross between *H. demissum* and *H. scabrum;* and that the recognition of the possibility of hybridisation, if made known, may assist collectors in naming these, as it were, transitional forms.

Art. XLV.—*A List of Plants growing at "The Gums," Taita.*

By T. Mason.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

In November, 1896, I submitted to the Society an account and list of the plants then growing in my garden at Taita, Lower Hutt.* I now present a list of the additions which have been made to my collection of growing plants since that date, which I hope may prove of some slight assistance to those who may wish to plant for themselves or futurity.

List of Plants.

Abelia hendersoni.
Abies
  macrocarpa.
  eichleri.
  numidica.
Abutilon vitifolium.
Acacia pycantha.
Acer
  circinnatus.
  campestre.
  tartarica.
Albuca canaliculata.
Andromeda
  arborea.
  ligustrina.
  calyculata nana.
  angustifolia.
  ovalifolia.
Anemone japonica (whirlwind).
Anoiganthus
  breviflorus.
  luteus.
Arundinaria falcata.
Asclepias tuberosa.
Aster
  tartaricus.
  turbinellus.
Baptisia leucanthe
Bellevallia spicata.
Berberis
  sanguineus.
  dulcis.
Bletia hyacinthus.
Boronia
  elatior.
  sp.
Brodiæa howelli.
Bulbocodium vernum.
Callistemon viridiflorum.
Calochortus amænus.
Camassia
  frazeri.
  leichtlinii.
Caryoptera mastacantha.
Cassinea rosmarinifolia.
Celastrus articulatus.
Cerasus
  ilicifolius.
  japonicus.
Cercis occidentalis.
Cereocarpus betulifolius.
Chænestes grandiflorus.
Chamerops gracilis.
Clematis
  viticella.
  velutina (grata).
Clianthus puniceus albus.
Coburgia
  incarnata.
  trichoma.
Colchicum
  montanum.
  steveni.
Convolvolus cneorum.

* Trans. N.Z. Inst., vol. xxix., p. 393.

Cornus nuttallii.
Coronilla emodi.
Corylus atropurpureus.
Crinum
  yemense.
  longifolium.
  capense.
Cupressus lambertianus aureus.
Cyanella lutea.
Cyclamen neapolitanum.
Cyrtanthus
  angustifolius.
  intermedius.
  macowani.
  sanguineus.
Cytisus elongata.
Daphne gingkwa.
Echinocea purpurea.
Edgworthia papyrifera.
Eleagnus longipes.
Embothrium coccineum.
Enkianthus japonicus.
Epimedium grandiflorum.
Erigeron mucronata.
Erythrina acanthifolia.
Erythronium grandiflorum citrinum.
Escallonia exoniensis.
Eucalyptus ficifolius roseus.
Euonymus
  europæus.
  fimbriata marginata.
Euscapus staphylloides.
Ferraria undulata.
Forsythia suspensa.
Fraxinus californicus.
Frittillaria
  persica.
  recurva.
  coccinea.
  imp. lutea.
  slagiourgand.
  rubra.
  sulphurina.
  imperialis.
    aurea.
  sessilis (var. californica).
Galaxia
  graminea.
  ovata.
Gillenia trifoliata.
Hæmanthus catherinæ.
Helianthus
  latifolius semi-pl.
  mamelliana.
Hemerocallis
  aurantius major.
  middendorfii.
Hesperanthus falcata.
Hovensis dulcis.
Hyacinthus
  suaveolens.
  nigrescens.
  moschatus luteus.
Hydrangea
  petiolaris.
  involucrata.
    plena.
Idesia polycarpa.
Incarvillia delavaya.
Iris
  pumila (various).
  orientale.
  gatesii.
  sindgarensis.
  cristata.
Kalmia
  angustifolia.
  rubra.
Lathyrus grandiflorus.
Leptospermum chapmanii.
Lespedeza bicolor.
Leucocrinium montanum.
Leucojum roseum.
Lilium
  croceum.
  wallachianum.
  washingtonianum purpureum.
  (white Turk's cap).
  hansoni.
  davuricum.
Lycoris
  squamigera alba.
  purpurea.

Lythrum coccineum.
Magnolia compressa.
Melanoschium decipiens.
Melia japonica.
Montbrezia crocosmæflora pl.
Morea flexuosa.
Morina longifolia.
Muscari
  botryoides candidum.
    commutatum.
    azureum.
Myosotidium nobile album.
Nerine
  angustifolius.
  amabilis.
  humilis splendens.
  novelty.
  undulatum.
  japonica alba.
Neviusia alabamensis.
Nierembergia frutescens.
Ornithogalum escapum, *β*.
Osteospermum lævigatum revolutum.
Pardanthus sinensis.
Pentlandia miniata.
Phalangea elegans.
Philadelphus
  microphylla.
  lemoinei erecta.
  grandiflora speciosum pl.
Photinia glabra.
Phyllirea angustifolia.
Phyllostachys
  mitios.
  quilloi.
Pittosporum tobira.
Polygonum filifolium.
Prumnopytis elegans.
Puschkinia
  libanotica compacta.
  scillioides.
Quercus
  acuta.
  dentata.
  phylleoides.
    trickers.
  cuspidata.
Quercus
  lævigata.
  hoskinsoniana.
  phellos.
  agrifolius.
  austriaca.
  lucombei.
    (cut leaf).
  lacera.
  sericia.
Ranunculus
  ficaria.
  monspellensis.
Rhododendron
  assamicum.
  suave.
  daviesii.
  arboreum glaucum.
Salix tenuifolius.
Sanguinaria canadensis.
Saxifraga granulata.
Scilla campanulata
  sibirica.
    major.
  hyacinthoides.
    rosea.
  patula rubra.
    grandiflora.
  pubina.
  ciliaris.
  bifolia rosea.
    grandiflora.
    natalensis.
  maritima.
Solidago canadensis.
Sophora pendula.
Spartagussus mubigenus.
Spirœa
  bumaldi.
  Ant. Waterer.
Staphylea bumaldi.
Sutherlandia frutescens.
Syringa
  siberica.
  Matthew Dombazle.
  Madame Lamoine.
Taxus
  elegantissimus.

Taxus
  fastigatus.
    variegated.
Trollius japonicus.
Tulipa
  gesneriana major.
  kaufmanniana.
  persica.
  dammani.
  præcox.
Ulmus
  campestre.
  vanhouttei.
Viburnum
  dilatatum.
  canadense.
Vitis
  elvira.
  odoratum.
Watsonia marginata.
Weigelia lamoinei.
Widdringtonia whytei.
Xanthoceras
  sorbifolia.
  picta.
Zauschneria californica.

ART. XLVI.—*On New Species of Grasses from New Zealand.*

By Professor E. HACKEL.

Communicated by T. F. Cheeseman, F.L.S.

[*Read before the Auckland Institute, 23rd February, 1903.*]

[THE grasses of New Zealand have long been in need of careful study and examination by some competent authority in Europe, whose position would give him access to the large European herbaria where the types of the published species are mainly deposited, and where it is alone possible to work out many questions relating to the geographical distribution of the species, and their relationship to the grasses of the world. No attempt to deal with the grasses of New Zealand with regard to these points has been made since the publication of Hooker's "Handbook of the New Zealand Flora" in 1864. Buchanan's beautifully illustrated work, which has appeared in the interim, though valuable in very many respects, is wholly confined to the illustration and description of the species, with notes on their economic value. During the forty years that has elapsed since the preparation of the "Handbook" the classification has been to a great extent revolutionised. Different views are now held as to the position and characters of many of the genera and species; and an immense amount of information has been obtained bearing on the geographical distribution of the species. Among the workers who have contributed to this advance no one is better known than Professor Eduard Hackel, of St. Polten, Austria. To say nothing of his monographs of the *Andropogoneæ* and European *Festuceæ*, his account of the whole order published in

Engler and Prantl's "Naturlichen Pflanzenfamilien" would alone place him in the first rank of European agrostologists.

During the preparation of the work on the "Flora of New Zealand," on which I am at present engaged, the necessity for a thorough investigation of the New Zealand grasses by some one possessing a special knowledge of the order became still more apparent. It was therefore with much satisfaction that I received an intimation from Professor Hackel that he was willing to undertake this, provided that he was supplied with a sufficient amount of fresh material from all parts of the colony. This, with the kind assistance of Mr. Petrie and Mr. Cockayne, who have contributed very large suites of specimens to the collection which I could withdraw from my own herbarium, I have been able to do. Professor Hackel's report on this collection and on the New Zealand grasses generally contains a large amount of valuable information, especially regarding the difficult genera *Agrostis*, *Deyeuxia*, *Danthonia*, *Poa*, &c., and will prove of the utmost service in the elaboration of the order for the forthcoming "Flora," for which I have his permission to use it. He has also furnished diagnoses in Latin of certain new species contained in the collection, which at his request I now submit to the Institute for publication in the Transactions.—T. F. CHEESEMAN.]

1. **Imperata cheesemani**, Hack.

Perennis, innovationibus extravaginalibus. Culmi subrobusti, erecti, ad 40 cm. alti, teretiusculi, glaberrimi, 3-nodes, simplices, farcti. Vaginæ foliorum laxæ, internodia superantes, teretiusculæ, ore barbatæ, ceterum glaberrimæ, summa paniculæ basin amplectens, infimæ squamiformes. Ligulæ breves, truncatæ, membranaceæ, glabræ v. ciliolatæ. Laminæ e basi valde angustata (in foliis basilaribus fere petioliformi) lineari-lanceolatæ, acutæ, inferiores ad 30 cm. longæ, 1·3 cm. latæ, superiores abbreviatæ, summa minuta, planæ, erectæ, rigidæ, glaberrimæ, costa media inferne crassa, nervisque lateralibus crassiusculis non prominentibus percursæ. Panicula spiciformis, anguste lanceolata a $\frac{1}{3}$ inferiore sensim angustata, acutissima, ad 20 cm. longa, 2 cm. lata, densa, canescenti-villosa, non nitens, rhachi glabra, ramis creberrimis sibi valde approximatis solitariis vel oppositis, erecto-patulis, flexuosis, glaberrimis vel pilis raris adspersis (inferioribus circ. 3 cm. longis), simplicibus v. inferne ramulis brevissimis auctis, fere a basi spiculiferis. Racemi ("spicæ") inferiores circ. 3 cm. longi, rhachi crassiuscula, glabra, internodiis circ. 12, quam pedicelli spicularum vix brevioribus, pedicellis crassiusculis, valde clavatis, glaberrimis, primariis circ. 2 mm., secundariis 1 mm. longis. Spiculæ lineari-oblongæ, 3·5 mm. longæ, villis e callo ortis spicula sesquilongioribus canescen-

tibus haud ita densis cinctæ, flavescentes. Gluma I. spiculam æquans, lanceolata, acutiuscula, membranacea, obscure 5-nervis, toto dorso laxe pilosa, apice ciliolata; II. I-æ simillima nisi obtusa, 3-nervis, apice dense ciliolata; III. quam I. ⅓ brevior, late ovata, obtusa, dentata, dentibus ciliolatis, hyalina, enervis, vacua; IV. quam II. ⅓ brevior, ovata, acuminata, tridentata, dentibus lateralibus quam intermedius multo brevioribus, glabra, hyalina; palea quam gl. II. duplo brevior, latissima, truncata, multidentata, fimbriato-ciliata. Stamen 1, anthera fere 3 mm. longa. Styli stigmataque elongata. Caryopsis oblonga, teretiuscula, 1·5 mm. longa, flavescens, scutello ⅔ caryopsidis æquante.

Kermadec Islands, leg. Cheeseman (Nro. 1001).

Affinis *T. exaltatæ*, Brogn., quæ differt a nostra culmo multo altiore, paniculæ ramis tenuissimis, ramulos secundarios crebros agentibus, racemorum rhachi capillari, pedicellis spicularum vix clavatis, spiculis linearibus, minoribus, glumis I. et II. acuminatis, manifeste 3-nerviis, III. glabra, IV. integra, palea gluma II. 4-plo breviore, integra.

2. **Agrostis petriei**, Hack.

Perennis, cæspitosa. Innovationes extravaginales, basi squamis aphyllis quoad longitudinem sensim majoribus vestitæ. Culmi erecti, graciles, ad 25 cm. alti, glaberrimi, 3–5-nodes, nodo summo fere in medio culmo sito, simplices. Vaginæ teretes, glaberrimæ, internodiis parum longioribus. Ligulæ oblongæ, ad 5 mm. longæ, obtusæ, denticulatæ. Laminæ lineares, sensim acutatæ, planæ vel siccitate convolutæ, glaucæ, ad 12 cm. longæ, 1·5 mm. latæ, utrinque scabræ, margine scaberrimæ, tenuinerves. Panicula oblonga, patula, laxiflora, ad 12 cm. longa, rhachi lævi, ramis 3–5-nis, capillaribus, scaberulis, a ⅓ inferiore divisis, primario circ. ⅓ paniculæ æquante, secundariis inferioribus paucispiculatis, tertianis plerumque unispiculatis, spiculis in apice ramorum subcontiguis, pedicellos subterminales apice vix incrassatos æquantibus. Spiculæ lineari-lanceolatæ, 3 mm. longæ, pallide virides; glumæ steriles æquales, lanceolatæ, acutæ, 1-nerves, læves; fertilis sterilibus ¼ brevior, tenui-membranacea, obtusa, minute denticulata, 4-nervis (infra medium 5-nervis), e medio dorso aristam exserens rectam, glumæ æquilongam raro mutica, callo pilis circ. 0·5 mm. longis obsita. Palea θ. Antheræ circ. 1·8 mm. longæ.

Nevis Valley, Otago, leg. Petrie (10044 hb. Petrie, 1092 hb. Cheesem.)

Var. *mutica*, arista nulla. Cromwell, Central Otago, Petrie (10045 hb. Petrie, 1085 hb. Cheesem.).

Affinis *A. caninæ* L., quæ differt a nostra foliis læte viridibus lævibus, panicula magis composita (ramulis tertianis

etiam plurispiculatis) densiore, spiculis minoribus (2–2·5 mm. longis), glumarum sterilium carina scabra, antheris vix 1 mm. longis. *Agrostis dyeri*, Petrie, differt a nostra (et ab A. canina) jam innovationibus intravaginalibus basi non squamatis. *A canina*, L., vera in Nova Zelandia nondum observata est; A. canina, Hook. f., Buchanan Manual t. xix. est A. dyeri, Petrie.

3. **Calamagrostis petriei**, Hack. (Sect. *Deyeuxia*).

Perennis. Culmi erecti, teretes, circ. 50 cm. alti, glaberrimi, trinodes, nodo summo prope medium culmi sito. Vaginæ teretes, arctæ, internodiis breviores longioresve, scaberulæ. Ligulæ inferiores obtusæ, vix 1 mm. longæ, superiores oblongæ v. obtusiusculæ, 2 mm. lg. Laminæ lineares, acutæ, inferiores ad 20 cm. longæ, 2·5 mm. latæ, planæ v. laxe involutæ, subtus glaberrimæ, supra marginibusque scaberulæ, rigidulæ, nervis valde prominentibus percursæ. Panicula linearis, contracta, ad 12 cm. longa, densiuscula, rhachi ramisque glaberrimis, his binis ternisve, brevibus (ad 2 cm. longis) rigidulis, post anthesin erectis, primariis basi breviter nudis 5–7-spiculatis, secundariis a basi spiculiferis 3–4-spiculatis, spiculis æqualiter dispositis quam pedicelli subterminales glaberrimi multoties longioribus. Spiculæ lineari-lanceolatæ, 6–6·5 mm. longæ, pallide virides. Glumæ steriles subæquales, anguste lanceolatæ, acutæ, rigide membranaceæ, uninerves, carina scaberulæ; gluma fertilis sterilibus ⅙ brevior (5 mm. lg.), lanceolata, acutiuscula, apice indistincte minuteque denticulata (nec bifida), membranacea, 5-nervis, dorso scabro-punctata, callo pilis ⅓ glumæ æquantibus densiuscule barbata, arista in media gluma inserta, recta, glumam æquante v. vix superante. Palea glumam subæquans, lineari-lanceolata, acutiuscula, bidentula, carina scabra. Rhachillæ processus gluma 3-plo brevior, pilis 3 mm. longis dense barbatus.

Swampy Hill, Dunedin, Otago, leg. Petrie (10092 hb. Petrie, 1190 hb. Cheesem.).

Cl. Petrie hanc speciem mihi nomine *Deyeuxiæ scabræ*, Benth., communicavit. Hæc, i.e. *Agrostis scabra*, R. Br., *Calamagrostis rudis*, Steud., a nostra valde distincta, differt spiculis parvis (3–3·5 mm. longis), pedicellis ramisque paniculæ scabris, gluma fertili steriles æquante v. subæquante, chartacea v. subcoriacea, obtusa, callo pilis paucis brevibus obsita, arista brevissima (0·6 mm. longa) multo supra medium dorsi inserta, rhachillæ processu quam gluma 4-plo breviore, brevissime et parcissime piloso (pilis 0·5 mm. longis). Propior est affinitas *C. petriei* cum *C. stricta*, Beauv.; quæ differt præsertim spiculis minoribus, gluma fertili callo longius barbata, arista infra medium dorsi inserta, rhachillæ processu brevissimo v. nullo.

4. **Trisetum cheesemani,** Hack.

Perenne. Culmi erecti, circ. 20 cm. alti, teretes, superne longiuscule nudi, ibique puberuli, binodes, nodo superiore in ¼ inferiore culmi sito, simplices. Folia in culmi basi aggregata: vaginæ subcompressæ, laxæ, internodiis longiores, glaberrimæ, emortuæ demum subfibrosæ. Ligulæ circ. 2 mm. longæ, truncatæ, denticulatæ. Laminæ e basi æquilata lineares, breviter acuminatæ, apice subcucullatæ, planæ, ad 5 cm. longæ, 4 mm. latæ, firmæ, erectæ, glabræ, supra læves, subtus scaberulæ, margine scabræ, glaucescentes, nervis supra prominentibus, crassis percursæ. Panicula spiciformis, linearis, densissima, 5–6 cm. longa, 1·5 cm. lata, rhachi ramisque minute puberulis, his binis ternisve brevibus fere a basi spiculiferis dense imbricatis, glomeratis, subterminalibus brevissime pedicellatis. Spiculæ lanceolato-ellipticæ, biflores, 6·5 mm. longæ, flavo-viridulæ, nitidæ, rhachilla altero latere breviter pilosa, ultra florem superiorem elongata. Glumæ steriles 5 et 6 mm. longæ, lanceolatæ, acutæ, I. uninervis, II. 3-nervis, quam fertilis superposita parum brevior, totæ scabræ, carina scaberrimæ. Glumæ fertiles lanceolatæ, circ. 5·5 mm. longæ, acutæ, apice brevissime acuteque bidentatæ, inter vel parum infra dentes mucrone 0·5–1 mm. longo recto instructæ, tenuissime 5-nerves, scabræ, carina superne scaberrimæ, callo brevissime laxeque pilosæ. Palea gluma ¼ brevior, oblonga, obtuse trilobulata, secus carinas scabras late implicata. Antheræ 1 mm. longæ. Ovarium glabrum.

Hooker Glacier, Mount Cook district, altit. 1200 m., leg. Cheeseman (Nro. 1221 sub nomine *T. subspicati*).

Species distinctissima, habitu, paniculæ spicularumque indole quidem *Triseto subspicato* similis, tamen propter glumas fertiles brevissime bidentatas et inter vel paullo infra dentes brevissime mucronatas (neque supra medium dors aristatas) non solum a T. subspicato, sed etiam ab omnibus genuinis *Trisetis* ita diversa, ut potius *Kœleriæ* generi adjungi possit. Re vera inter hoc et *Trisetum* limites certi non inveniuntur, qua re inductus jam cl. Desvaux in Gay, Fl. chil. vi., p. 352, Kœleriam ad Triseti sectionem reduxit.

5. **Poa novæ-zelandiæ,** Hack. Syn. *P. foliosa* var. B. Hook. f., Handb. N.Z. Fl. i., 338; Buchan., Man. tab. 43A.

Perennis, cæspitosa, innovationibus intravaginalibus v. mixtis. Culmi erecti, 2–3 dm. alti, graciles, teretes, glaberrimi, superne breviter nudi, 3-nodes, nodo summo circ. in medio culmi sito. Folia glaberrima: vaginæ plus minusve laxæ, internodiis plerumque breviores, innovationum compressæ, emortuæ stramineæ, diu persistentes, demum subfibrosæ; ligulæ ovales, acuminatæ, 4–5 mm. longæ, sæpe

dentatæ; laminæ e basi æquilata lineares, subito acuminatæ, erectæ, rigidulæ, 10–20 cm. longæ, culmeæ planæ ad 8 mm. latæ, innovationum complicatæ (expansæ 2–4 mm. latæ), virides, nervis haud prominentibus tenuibus percursæ. Panicula ovata v. ovato-oblonga, ad 10 cm. longa, densa, subnutans, subcontracta, rhachi ramisque lævibus, his binis ternisve capillaribus, in $\frac{1}{3}$–$\frac{1}{2}$ inferiore indivisis, dein ramulos secundarios 2–6-spiculatos tertianosque 1–2-spiculatos subappressos agentibus, spiculis versus apicem ramorum congestis, imbricatis, subterminalibus brevissime pedicellatis. Spiculæ elliptico-oblongæ, 5–6-flores circ. 8–10 mm. lg., valde compressæ, virides v. pallidæ; glumæ steriles 3 mm. et 4 mm. longæ, acutissimæ, glaberrimæ, I. subulato-lanceolata, 1-nervis, II. lanceolata, 3-nervis, paullo ultra mediam IV-am pertinens; glumæ fertiles anguste lanceolatæ, acutissimæ, 5 mm. longæ, callo villis crispulis glumam dimidiam æquantibus v. superantibus vestita, ceterum glaberrima, nervis lateralibus extremis parum, intermediis minime prominentibus, sæpe omnino obsoletis. Palea gluma $\frac{1}{3}$ brevior, lineari-oblonga, acute bidentata, carinis scabro-puberulis. Antheræ 3, 1·2 mm. longæ. In regione subalpina et alpina montium late divulgata et satis variabilis. Vidi specimina formæ typicæ e locis sequentibus: Canterbury Alps ad Arthur's Pass, altit. 1000 m. (Cheesem. nr. 1338, 1339) et Hooker Glacier (Cheesem. 1341), Nelson mountains ad Mount Arthur Plateau (Cheesem. 1340), Humboldt Mountains (Cockayne, 1347 in hb. Cheesem.).

Forma *laxiuscula*, culmo elatiore, panicula laxiuscula valde nutante, viridi.—Bealey Gorge, Canterbury Alps, alt. 1000 m. (Kirk, nr. 1373 hb. Cheesem.).

Forma *humilior*, culmo 6–8 cm. alto, foliis circ. 3 cm. longis, 1·5–3 mm. latis, panicula 3–4 cm., minus composita, spiculis subcoloratis 7 mm. longis, glumis sterilibus $\frac{2}{3}$ fertilium æquantibus, lanceolatis.—Mount Hikurangi, East Cape, alt. 1500 m. (Petrie 10198, hb. Cheesem. 1345); Otira Glacier, Westland, alt. 1160 m. (Cockayne 6557, in hb. Cheesem. 1348); Raglan Range, Wairau Valley, Nelson Alps, 1500 m. (Cheesem. 1342).

Var. *subvestita*, glumis fertilibus 6 mm. longis in $\frac{1}{3}$ inferiore carinis villis crispulis vestita, nervis lateralibus exterioribus prominentibus, superne violaceo-tinctis. — Central Otago (Petrie 10197, in hb. Cheesem. 1344); Arthur's Pass, Canterbury mountains, cum forma typica (Cockayne 6566, in hb. Cheesem. 1346).

Poa foliosa, Hook. f., vera differt a nostra culmo elato (50 cm. v. ultra), foliis elongatis (30 cm. v. plus) longe acuminatis, supra scabris, nervis crassiusculis sed non prominentibus percursis, paniculæ magnæ (circ. 20 cm.) ramis fere a

basi spiculiferis, spiculis secus ramos æqualiter dispositis, glumis fertilibus distincte 5-nerviis, nervis non solum externis sed etiam intermediis prominentibus, carina ad ½ usque atque nervis marginalibus in ⅓ inferiore crispato-villosulis ceterum undique scabris. Palea gluma ⅓ brevior. Specimina mea (Herekopere Island, l. Kirk, Snares prope Stewart Island, l. Petrie) staminibus valde hebetatis fœminea.

6. **Poa polyphylla**, Hack.

Cæspitosa, innovationibus extravaginalibus. Culmi erecti v. arcuato-ascendentes ad 30 cm. alti, compressi, glaberrimi, polynodes, foliis 7–17 inferne valde approximatis distiche patentibus vestiti, basi ramosi. Vaginæ sese invicem arcte involventes, internodiis saltem inferioribus multo longiores, glaberrimæ. Ligulæ brevissimæ, truncatæ, marginiformes. Laminæ e basi æquilata anguste lineares, sensim valde acutatæ, planæ v. laxe complicatæ, ad 20 c.m. lg., 2 mm. latæ, patentes, glabræ, inferne læves, superne (saltem infra apicem) marginibus carinaque scabræ, nervis crassiusculis sibi valde approximatis percursæ. Panicula oblonga, contracta, densa v. densissima, ad 8 cm. longa, 1·5 cm. lata, rhachi ramisque lævibus, his binis suberectis, a basi v. fere a basi plus minusve dense spiculiferis, ramo primario circ. 2–3 cm. longo ramuloso multispiculato, spiculis imbricatis, subterminalibus brevissime pedicellatis, pedicellis scabris. Spiculæ oblongæ, 4–5-flores, 5–6 mm. longæ, floribus ad ¾ longitudinis sese tegentibus, viridulæ. Glumæ steriles 2·5 mm. et 3·5 mm. longæ, lineari-lanceolatæ, acutæ, ⅔ fertilium tegentes, carina aculeolato-scaberrimæ, 1-nerves. Glumæ fertiles lineari-lanceolatæ, mucronulato-acuminatæ, 4 mm. longæ, 5-nerves, nervis prominulis, callo pubescentes, ceterum glabræ, undique (præsertim ad nervos) scabræ, carina aculeolato-scaberrimæ. Palea glumam subæquans, lineari-oblonga, acute bidentata, carinis scabra.

Kermadec Island, leg. Shakspear (in herb. Cheesem. 1444–46). Forma *compacta:* panicula densissima, spiculis dense imbricatis (1445).

Affinis *P. ancipiti*, Spr., quæ a nostra differt foliis in singulo culmo 3–4-nis, erectis, apice parum attenuatis, abruptius acuminatis, undique lævibus, panicula laxiore, ramis primariis ad ½ usque nudis, glumis fertilibus basi brevius et parcius lanatis apice acutiusculis v. obtusiusculis, vix scaberulis.

7. **Poa cheesemani**, Hack.

Perennis, haud cæspitosa, rhizoma stolones basi squamis aphyllis 2–3 instructos et subterraneos et supraterraneos agens. Culmi erecti, ad 40 cm. alti, teretes, glaberrimi, 3-nodes, nodo summo in ½ culmi sito. Vaginæ internodiis

breviores, subcompressæ, superne carinatæ, glaberrimæ. Ligulæ truncatæ, 2 mm. longæ, lineares, obtusiusculæ, siccando plus minusve arcte complicatæ, statu complicato 1–1·5 mm. latæ, ad 12 cm. (summa vix 2 cm.) longæ, erectæ, rigidulæ, virides, glaberrimæ, intus costis crassiusculis depressis sese fere tangentibus percursæ. Panicula ovata, laxa, patens, circ. 8 cm. longa, rhachi lævi subflexuosa, ramis inferioribus ternis subcapillaribus in $\frac{2}{3}$ inferiore indivisis et lævibus, sæpe rubellis, superne ramulos paucos unispiculatos parce scabros agentibus, spiculis n apice ramorum laxiuscule aggregatis, subterminalibus pedicellos circiter æquantibus. Spiculæ ellipticæ, 5–6-floræ ad 8 mm. longæ, livide virides et subrufescentes, densifloræ. Glumæ steriles 3·5 mm. et 4·5 mm. longæ, late lanceolatæ, acutæ, 3-nerves, carina læves, $\frac{5}{8}$ v. $\frac{7}{8}$ glumarum fertilium superpositarum tegentes; fertiles late lanceolatæ, acutæ, 5 mm. longæ, prominule 5-nerves, callo pilis porrectis haud contortuplicatis neque protrahendis circ. dimidiam glumam æquantibus vestitæ, carina nervisque submarginalibus in $\frac{1}{3}$ v. $\frac{1}{4}$ inferiore parce villosæ, ceterum læves; palea glumam subæquans, oblonga, acute bidentula, carinis serrulato-scabris. Antheræ 2 mm. longæ.

Nelson Alps, Lake Tennyson, altit. 1000 m., leg. Cheeseman (Nro. 1316).

Iterum affinis est *P. ancipiti*, Spr., præsertim ejus varietati *tenuiori*, Hack., tamen certe differt rhizomate stolonifero. Nam in *P. ancipite* rhizoma cæspitosum est, sine stolonibus. Spiculæ *P. ancipitis* oblongo-ellipticæ sunt, glumæ steriles respectu fertilium breviores, nam vix $\frac{2}{3}$ earum tegunt. Habitu et innovationis modo species nostra ad *P. pratensem*, L., europæam accedit, quæ vero glumis fertilibus basi lana longa contortuplicata atque protrahenda vestitis aliisque notis satis differt.

8. **Festuca ovina** subspec. **novæ-zelandiæ**, Hack.

Culmi circ. 30 cm. alti, trinodes, scabri; foliorum vaginæ fissæ, glaberrimæ, laminas emortuas diu retinentes; ligulæ manifeste biauritæ, glabræ; laminæ cylindricæ, grosse setaceæ v. subjunceæ (diam. 0·7 mm.) acutissimæ, rigidulæ, sub epidermide inferiore stratis sclerenchymaticis 2–3 continuis v. inter nervos subinterruptis instructæ, circ. 25 cm. longæ (culmum subæquantes), virides, extus punctis scabris v. aculeolis conspersæ. Panicula oblonga, subcontracta, laxiuscula, ramis binis in $\frac{1}{2}$ inferiore nudis, 3–6-spiculatis. Spiculæ ellipticæ, 5–7-flores, ad 10 mm. longæ; glumæ steriles lineari-lanceolatæ, II. ad $\frac{3}{4}$ IV-æ pertinens, fertiles anguste lanceolatæ, mucronatæ v. brevissime aristulatæ, glabræ, scaberulæ, 5·5–6 mm. longæ. Palea glumam subsuperans, carinis scabra. Antheræ 3 mm. longæ.

Canterbury Alps, in declivibus montis Torlesse, altit. 1000 m., leg. Cheeseman (Nro. 1497 sub nomine *F. duriusculæ*, L.).

Habitus *F. ovinæ* var. *duriusculæ*, quæ vero differt a nostra foliis ipso apice obtusiusculis, lævibus, culmo lævi, panicula patente, spiculis minoribus. Inter subspecies *F. ovinæ* in Monographia Festucarum europæarum mea recensitas maxime accedit ad subsp. *beckeri*, quæ præsertim differt foliis lævissimis, vaginis laminas emortuas mox dejicientibus, spiculis minoribus.

9. **Festuca ovina** subsp. **matthewsii**, Hack.

Culmi erecti circ. 30 cm. alti, binodes, nodo superiore in medio culmi sito, glaberrimi. Innovationes oligophyllæ, elongatæ. Vaginæ laxiusculæ, fissæ, glaberrimæ, demum fuscæ, laminas diu retinentes. Ligulæ bilobæ, lobis fere 1 mm. longis acutiusculis ciliolatis. Laminæ anguste lineares, complicatæ, imo apice acutiusculæ, 20–25 cm. longæ (culmum subæquantes), statu complicato 0·7–0·8 mm. diam. basi pulvinari calloso fusco instructæ, extus glaberrimæ, siccæ costatæ, intus puberulæ, sectione transversa obtuse hexagonæ, 5-nervo, sub singulis nervis singulis fasciculis sclerenchymaticis plerumque tenuibus instructæ. Panicula ovato-oblonga, circ. 14 cm. longa, patula, laxa, subnutans, rhachi ramisque scabris, his binis, basi longe nudis, apice 1–3-spiculatis. Spiculæ ovato-lanceolatæ, 5–7-flores, ad 16 mm. longæ, subterminales breviter, reliquæ longe pedicellatæ, densifloræ. Glumæ steriles inæquales, lanceolatæ, acutæ, læves, II. ad medium IV-æ pertinens, fertiles, lineari-lanceolatæ, acutæ, 8 mm. longæ, in aristam 2–3 mm. longam abeuntes. Palea glumam æquans v. subsuperans, lineari-lanceolatæ, subulato-bidentata, carinis scaberula. Antheræ 3 mm. longæ. Ovarium glabrum.

Mount Bonpland, Otago, leg. H. J. Matthews (hb. Cheesem. 1496).

Subspecies peculiaris, fere species propria dicenda. Ab omnibus subspeciebus *F. ovinæ* differt spiculis maximis et corpore calloso pulviniformi in basi laminarum, cujus ope, ut videtur, lamina a vagina culmoque removitur. Inter Festucas europæas ad *F. amplam*, Hack., accedit, inter asiaticas ad *F. nubigenam*, Jungh., quæ ambæ jam spiculis minoribus distinguntur.

IV.—GEOLOGY.

Art. XLVII.—*The Kingston Moraine.*

By Dr. P. Marshall.

[*Read before the Otago Institute, 8th July, 1902.*]

During a short stay at Kingston in March, 1902, an examination was made of the moraine at the south-east end of Lake Wakatipu. The examination was made with the object of finding, if possible, the limits of the area from which the ice forming the large glacier that formerly filled the lake-basin was derived.

The materials of the moraine were found to consist almost entirely of mica-schist, phyllite and aphanite breccia, which constitute the mass of the mountain-ranges by which the lake-basin is bounded.

On the shore of the lake the materials of the moraine have been subjected to a sorting action by the breaking waves, and those stones consisting of the more resistant materials have become more concentrated. On this beach, about a mile from the hotel, were found twelve stones which, in consequence of their absence from the rock-masses near the lake, offered suitable material for study. These rocks may be classified as follows:—

(B 102.) *Granite.*—Light-grey rock of even granular appearance. Except for decomposed feldspar, the separate minerals cannot be distinguished. Section: Quartz in clear grains completely allotriomorphic. Feldspar completely decomposed, revealing nothing of its original nature. Decomposition products chiefly quartz and muscovite flakes with epidote. A few small grains of amphibole of a fibrous structure with strong pleochroism. Small grains of biotite with strong absorption occur here and there in groups without any relation to the neighbouring minerals. The actinolitic amphibole and biotite are evidently secondary in their origin.

(B 101.) *Granite.*—Similar to B 102 in general appearance. Section: Similar to B 102, but the feldspar is much fresher, and is found to consist partly of orthoclase, partly of oligoclase, and perhaps albite. Plagioclase is more plentiful than orthoclase, and is twinned freely on the albite law and

occasionally on the pericline. The actinolitic hornblende mentioned in B 102 is not present here, but the groups of brown mica plates are rather more numerous.

(B 103.) *Gneiss.*—A white rock consisting of an even-grained mixture of quartz and feldspar, with a few plates of biotite. In the hand specimen a gneissic structure can be seen. Section: Quartz completely allotriomorphic; is very abundant. Feldspar generally twinned only on the Carlsbad law, but sometimes oligoclase on the albite law and frequently in smaller crystals, showing a further development of pericline twinning, giving an appearance almost similar to that of microcline. Slightly decomposed into grains that are for the most part muscovite plates. Biotite in fairly large grains is not infrequent; it is evidently an original constituent. A few grains of zircon and magnetite, and a little apatite.

(B 107.) *Aplite.*—Hard compact rock, light-green. Separate grains not distinct. Section: Quartz in irregular clear grains, allotriomorphic. Feldspar much decomposed. Decomposition products needles of a light-green colour, probably epidote, and plates apparently of muscovite. Optical properties not entirely lost by decomposition, and much is evidently orthoclase. Other crystals show albite and occasionally pericline twinning. Extinction angle of lamellæ small, showing the mineral to be oligoclase. The only ferromagnesian constituents are very scarce; biotite mica plates partly converted into chlorite. The green colour of the rock, which in hand specimens is conspicuous, is entirely due to the epidotic decomposition products of the feldspar. The specimen is penetrated by small microscopic quartz veins. The specimen has sandstone adhering to it, and is evidently a dyke rock.

(A 188.) *Syenite.*—Very compact, showing dark crystals of hornblende of even size arranged in a white feldspathic material, which weathers on the surface into a light-green tint. Section: Feldspar almost opaque owing to complete decomposition. Products of decomposition fine colourless needles, with low refractive index and very weak birefringence, probably kaolinite. No twinning can be detected in the small patches of feldspar remaining clear, so it is probably orthoclase. Hornblende much bleached, apparently originally brown. Absorption, α, light-straw colour, β, greenish-brown, γ, brown, $\gamma > \beta > \alpha$. In the bleached portion of the crystals there is barely any noticeable absorption. Cleavage traces much bent and distorted in longitudinal section.

(B 106.) *Syenite.*—Generally similar in section and hand specimen to A 188, but much finer-grained. It is evidently a portion of the same mass.

(B 104.) *Diorite.*—An even-grained light-green rock in which the hornblende and feldspar can be distinguished readily. Section: Feldspar twinned on albite and pericline laws. Extinction angle indicates a basic oligoclase or andesine. Very slight cloudiness indicates the commencement of decomposition. Hornblende light-green, showing the usual absorption. Quite fresh. Magnetite generally in irregular masses, but occasionally idiomorphic, is common. Apatite needles pierce through the hornblende.

(B 105.) *Diorite.*—Light-green rock, with white feldspar crystals and light-green hornblende. Not porphyritic in habit. Section: Feldspars all plagioclase and giving extinction angles characteristic of andesine. Albite and pericline twinning common. Amphibole completely fibrous, with irregular terminations. Light-green in colour and slightly pleochroic. Fibres differ slightly in optical properties, showing a striated appearance between crossed nicols. Probably all secondary, the amphibole being actinolite. Magnetite in small grains occurs throughout the section.

(A 161, 193, 194.) *Feldspar Porphyrite.*—Dark-green base, with distinct light flesh-coloured phenocrysts of feldspar, of tabular habit. Sections: Feldspar phenocrysts twinned polysynthetically on albite law and Carlsbad. Maximum extinction angle on sections perpendicular to 010 32°, indicating a feldspar of a rather acid labradorite type. Thickly dusted with decomposition products, which from their high birefringence and colourless nature appear to be muscovite scales. Groundmass consists of feldspar microlites, apparently labradorite much decomposed contained in a fine-grained mixture of green amphibole and brown mica. The amphibole shows no crystalline boundaries. It is highly pleochroic in shades of green. Maximum extinction 18° with the cleavage. Structure fibrous. Mica in very small plates. No distinct outline. From their arrangement it is almost certain that the last two minerals are secondary.

(A 187.) *Porphyrite.*—A black rock with weathered surface, covered with rounded hard resistant knobs. Generally similar to the groundmass of A 161. Section: Feldspar fairly large grains, penetrated through and through with epidote needles. Optical properties can still be distinguished in some of the crystals, and prove them to be labradorite. Amphibole, where original, very light-green, with ordinary absorption and twinning; where secondary, bright-green and actinolitic. Brown mica in small plates, probably secondary. Magnetite generally scattered through the rock.

(A 156.) *Forellenstein.*—Light-grey rock, with undecomposed feldspar showing bright cleavage planes. Not porphyritic. Section: Very fresh feldspar without idiomorphic

boundaries. Twinned repeatedly according to albite and pericline laws, as well as Carlsbad. Lamellæ generally broad. Extinction angle in sections perpendicular to 010 high in a few instances, proving the mineral to be anorthite olivine with rounded boundaries. Irregular cracks penetrating it, bordered by magnetite, and occasionally serpentine. A few grains of hypersthene showing strong pleochroism associated with the olivine. A few scattered grains of magnetite.

Of the rocks described above, syenites have been mentioned in the Geological Survey reports as occurring in many distinct localities within the drainage-basin of the lake as intrusive rocks. The diorites, granites, gneiss, and forellenstein are similar to some of the types classified together by the Survey as crystalline schists. These rocks are particularly characteristic of the Sounds region, though the distribution of the different types has not yet been ascertained in any of the districts where they occur. The porphyrite is a type that has not been recorded within this district by the officers of the Survey.

From the descriptions given it will be seen, on reference to a geological map, that these rocks must have been derived from various sources. In the "Reports of the New Zealand Geological Survey, 1879–80," p. 129, a map is given illustrating the results of an examination of the country to the north and west of Lake Wakatipu by Mr. A. McKay. In this map the nearest outcrop of crystalline schists to the lake is that in the Hollyford Valley. It is stated in this report that the depth of the Hollyford Valley is the cause of the appearance of these rocks. The report states that syenites occur as intrusive masses in many places between the Maitai and Te Anau series, and as several junctions of these two series are shown within the present drainage-basin of the lake their presence in the moraine was to be expected.

The country further to the north and east was examined by Professor Park in 1886–87 ("Geological Survey Reports, 1886–87," p. 121). The map accompanying the report shows crystalline schists on the west side of the Humboldt Mountains, again outside the present drainage-basin. These are the only notices I can find of these rocks near the lake.

A specimen of a rock quite similar to the porphyrite was brought me from the Kawarau gravels, and, as this rock is from its nature certain to be local in its occurrence, it must, in the absence of other evidence, be taken as probable that the two rocks come from the same locality.

These results are of some interest, for the presence of the "crystalline schists" shows that, if the occurrence of these rocks is correctly mapped, the ice of the Wakatipu glacier must have been partly derived from an area now beyond the

watershed of the streams flowing into the lake, or the ice forming the glacier scooped them up from the bed of the lake. So far as our stratigraphical knowledge of the district goes, the latter explanation is possible, for the crystalline schists at the Hollyford underlie the Te Anau series. This latter series also borders the west side of the upper portion of the lake, and, as the lake has a depth of 1,200 ft., it is possible that the underlying rocks may be exposed in the bed of the lake. Several instances are on record of rocks having been raised by ice-action from low to high levels.

The presence of the porphyrite strongly supports Captain Hutton's theory that a glacier from the Shotover acted as a tributary to the Lake Wakatipu glacier.

Whether these rocks now occur in the drainage-basin of the lake or not, there is no doubt that the lake-bed must once have been the bed of a large glacier which existed long enough for rock-fragments to be borne some hundred miles on its surface. A record of their occurrence may therefore be of service hereafter, when sufficient facts have been collected to enable us to solve for ourselves the question on its own merits whether the rock-basin of Lake Wakatipu owes its origin to glacial erosion or earth-movements. Earth-movements in the mountains bordering the lake must almost certainly be recorded by the tilting of the terraces formed round the lake-shores. No accurate measurements of the height of these terraces in different portions has yet been made, though Mr. McKay mentions such terraces at a height of 1,000 ft. near Queenstown, and at 300 ft. further up the lake. He does not, however, say that his observations refer to different parts of the same terrace.

ART. XLVIII.—*On the Geology of the Rock-phosphate Deposits of Clarendon, Otago.*

By Professor JAMES PARK, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 11th November, 1902.*]

THE discovery of rock-phosphate was made some two years ago by Mr. Ralph Ewing, of Whare Flat, Dunedin, who qualified himself for the work of prospecting by a personal study of the phosphate-deposits of the United States of America. Mr. Ewing, on his return from America, made a systematic search of the east coast districts of Canterbury and Otago, and finally located the present deposits on what

is now a portion of the Horseshoe Estate situated near Clarendon Railway-station, a place thirty miles south of Dunedin. Subsequent search has shown that phosphatic rock occurs in many places on the estate and adjoining properties, including, among other places of interest, the well-known lime-quarries at Millburn.

In June of this year I was enabled through the courtesy of the owners to make an examination of the geological conditions under which the phosphate occurred. The result of my investigation was contained in an article contributed to the *Otago Witness* in July* of this year. After an interval of five months I again visited the locality, with the view of collecting any fresh facts disclosed by the extensive mining operations undertaken during that period. The result of my observations on both occasions is contained in the present paper.

Physical Features.

From the low-lying valley at the south end of Waihola Lake, along which the Dunedin–Invercargill Railway runs to Milton, the land rises to the westward by a succession of low, gentle, undulating hills, from which, by a long easy slope, is reached the summit of the semicircular ridge whose contours probably suggested the present name of the estate. The point of the horseshoe is directed toward Milton, with the Millburn quarries on the outer rim and Horseshoe Bush on the inner. The summit of the ridge is fairly flat. The descent into the bend is long and easy, but on the Milton side it is generally abrupt, and in many places quite precipitous.

The surface is open agricultural land, much of which is at present under cultivation.

General Geological Structure.

The general geological structure of the district is very well seen in the section running from Clarendon westward across the Horseshoe Estate, for a distance of perhaps a mile and a half from the railway-line. After leaving the flat the low hills first crossed are composed of mica-schist of probably Silurian age, lying nearly horizontal. Proceeding westward, the schist is overlain by Upper Eocene quartz grits and conglomerates which usually form the lowest member of the coal-measures in southern Otago. The grits are in turn followed conformably by glauconitic greensands, limestones, often glauconitic, and a soft brown sandstone. The latter is overlain by a flow of basalt which caps the horseshoe ridge referred to above. The series of beds associated with the limestone lies nearly horizontal in the Horseshoe Bend,

* *Otago Witness*, 16th July, 1902.

but rises gently to the south-west, the inclination for the most part being so gradual as to be perceptible only by comparing the altitudes of the limestone outcrops over wide intervals. The phosphate rock, to be more particularly described hereafter, occurs in pockets in the limestone, and is covered in most places with an overburden of brown-coloured sands and clays.

A study of the topographical features of this area, when considered in connection with the disposition of the rock formations, shows that the present contours were determined by denudation long after the eruption of the basalt cap.

CLASSIFICATION OF ROCK FORMATIONS.

For purposes of description and correlation the rock formations present in this district may be classified according to their respective ages as follows, excluding the recent alluvia of the flats and swamps :—

Post-Miocene	Basalt flow.
Oamaru series (Upper Eocene)...	*a.* Brown sandstone.
	b. Limestone.
	c. Glauconitic sandstone.
	d. Quartz grits and conglomerates.
Silurian	Mica-schist.

Silurian.

The mica-schist crops out behind Cemetery Hill, about 45 ft. above the surface of Waihola Lake. It forms the basement rock of this and surrounding districts, cropping out along the western boundary of the Horseshoe Estate, whence it extends westward and northward throughout Central Otago.

Near the cemetery, and all around, the schist lies in a nearly horizontal position, but it would not be safe from this to conclude that it had occupied this position from the time of its formation until now. A rock of such antiquity must of necessity have been subjected to all the stresses and foldings which affected the younger formations in this region ; and it is only reasonable to conclude that the direction of the later secular movements has tended to flatten the Silurian strata, which prior to these later movements were probably highly inclined.

Upper Eocene.

(*d.*) *Quartz Grits and Conglomerates.*—These ride hard on the mica-schist, from which the contained quartz grains and pebbles were derived. Here, as elsewhere throughout

southern Otago, the cementing medium of the grits is brown peroxide of iron, and here also these beds possess their usual flaggy structure. Where the iron-peroxide occurs in large excess it presents a fine mammillary structure incrusted on the flat surface of the grit-stone.

These quartz grits, generally known as coal grits from their close association with the brown coals of Otago, in most places contain traces of gold originally derived from the schists from which they were formed. And, although the grits themselves have seldom or never been found sufficiently rich to be worked directly for their gold contents, it is, nevertheless, of importance to mention that much of the alluvial gold of Otago has been derived from a rewash of the grits in which the gold has been collected in a more concentrated form.

The area occupied by the grits is much obscured by surface earths and masses of basalt, which render it impossible to measure the thickness of these beds, or ever determine whether the fireclays and brown coal which usually accompany them are present here or not.

(*c.*) *Glauconitic Sandstone.*—This rock is well exposed at the phosphate-quarry workings at Kiln Point, opposite Clarendon, and at Millburn quarry. The section at the former place is obscured with slope deposits, and in consequence the thickness of the sandstone could not be determined accurately, but it is probably not less than 40 ft. or 50 ft. At Millburn a thickness of 40 ft. is visible below the limestone, and there also the base of the section is not seen.

The sandstone is generally coarse in texture, and, except where it is highly calcareous, never shows any planes of stratification. It contains a considerable proportion of glauconite, the hydrous silicate of iron and alumina to which the rock owes its greenish colour.

At Kiln Point this sandstone was found to contain a few species of marine *Mollusca*, mostly broken and fragmentary. Of these were collected a large smooth *Pecten*, probably *Pecten hochstetteri;* a small *Pecten* with large distinct ribs, probably *P. williamsoni;* and *Serpula.* In addition to these Mr. R. Ewing found a very large shark's tooth.

At Millburn quarry were found *Pecten hochstetteri*, a fragment of a large strongly ribbed *Pecten* or *Lima*, *Serpula* (two species), *Balanus*, and a species of small oyster. And at the Millburn Company's phosphate-workings, which are situated about a quarter of a mile east of the quarry, from the greensand where oxidized to a rusty-brown colour were collected a *Turbo*, *Voluta*, *Leda*, *Tapes*, *Venus*, *Waldheimia*, *Dentalium*, *Flabellum*, and fish-teeth.

These forms are all characteristic of shallow-water con-

ditions, and show that the sediments forming this sandstone accumulated near the shore-line of a shallow sea, with shoals of rock and stretches of clear sand. On the other hand, the mineral glauconite is known to be formed by filling or replacing organic bodies, generally Foraminifera, by a process of slow replacement, molecule by molecule, under conditions which would require the absence of strong sea-currents and a coast-line free from the encroachment of fluviatile deposits.

(*b*.) *Limestone.*—This rock has its greatest development at Millburn quarry, where there is a face exposed showing a thickness of about 65 ft. The total thickness from the highest pinnacle down to the upper surface of the glauconitic sandstone is probably 80 ft.

In the phosphate-quarry at Kiln Point only the lower horizon of the limestone is exposed; while at Millburn both the lower and upper horizons are seen. The lower horizon, comprising, perhaps, a thickness of 25 ft., is speckled with glauconite, and, being sandy or arenaceous, forms an inferior limestone. The upper horizon is dull-grey in colour, almost free from glauconite, and of purer quality than the lower. It is often flaky and splintery, and, being fine-grained and earthy in some places, bears a strong superficial resemblance to the Amuri limestone of northern Canterbury, with which, however, it has no connection.

In the spoil-heap of the quarry at Millburn were found the jaw and teeth of a *Zeuglodont* whale, *Pecten hochstetteri*, *Meoma crawfordi*, a *Waldheimia*, a branching net coral, and a solid coral.

This rock is the horizontal or time-equivalent of the Oamaru stone, which is the closing member of the New Zealand Lower Tertiary coal-bearing formation. It is the most characteristic and persistent member of that formation, and is seldom or never absent where coal is found. It occurs throughout both Islands, and is everywhere easily distinguished. In places, through the scarcity of lime, it is little more than a calcareous sandstone or impure limestone; while in other places it is very pure and highly crystalline in structure.

In different districts it has received the name of the locality in which it is found. Thus, in Southland it is called the "Winton limestone"; in Bruce country, the "Milton or Millburn limestone"; in North Otago, "Oamaru stone"; in South Canterbury, the "Waihao limestone"; in North Canterbury, "Weka Pass stone"; at Mokau, "Mokau limestone"; in the King-country, "Te Kuiti limestone"; at Raglan, "Raglan limestone"; in Waikato, "Taupiri limestone"; while at Whangarei, Hikurangi, Kawakawa, and Waipu it has received these names respectively; and so also

in many other localities which need not be specified it has been designated by a local name.

This limestone is very variable in physical character and composition. Even in the same horizontal plane it may be seen to pass gradually and insensibly from a compact limestone into a calcareous sandstone, often within a distance of half a mile or less.

(*a.*) *Brown Sandstone.*—From the upper surface of the limestone to the basalt cap there is an interval of 120 ft. to 150 ft. in vertical height, apparently occupied by a yellowish-brown sandstone, the character and disposition of which could not be ascertained on account of its outcrop being obscured by a heavy slope deposit of black earth mixed with sand.

In the Oamaru and Weka Pass districts, where the sequence of Lower Tertiary strata is very complete and characteristic, the Oamaru and Weka Pass calcareous sandstones, which, as we have seen, are the time-equivalents of the Millburn limestone, are followed quite conformably by the Hutchison quarry, or Mount Brown beds, which consist of yellowish-brown calcareous sandstones containing a rich assemblage of marine forms. This overlying series is so closely associated with the Oamaru series that it cannot be regarded as a separate formation, but only as the closing horizon of the Oamaru series itself. Until something more definite is ascertained about the sandstone lying above the limestone on the Horseshoe Estate, it may be correlated with the Hutchison quarry horizon of the Oamaru formation.

Basalt.

This occurs as a true flow. It rests on the upper surface of the brown sandstone and caps all the higher hills. As its junction with the underlying rock is everywhere obscured by slope deposit, its thickness cannot be determined, but at the old cemetery quarry the depth of the flow is not less than 100 ft.

This basalt is excessively fine in texture, at most places possessing a clean, splintery fracture. In the face of the cemetery quarry it exhibits a rudely columnar structure. Here, also, its weathered surfaces possess a deeply corroded appearance, and the usual splintery character is absent except in one narrow band near the centre of the higher part of the quarry-face.

In polarised light thin slices of this rock show an abundant dull-grey or semi-opaque feldspathic base, with augite and olivine, the latter often serpentinised. Idiomorphs of feldspar are absent. The base, however, is crowded with acicular microlites, some of which appear to exhibit polysynthetic twinning. Magnetite is very abundant.

In the absence of rocks overlying the basalt it is impossible to fix the date of its eruption even approximately. In his work on the "Geology of Otago" (1875, p. 56), Captain Hutton, F.R.S., considers the basalt at the head of Waihola Lake, with which this basalt has probably some association, to be contemporary with his Oamaru formation of Lower Miocene age; but the evidence on which this conclusion is based is not given.

At Cemetery Hill the flow rests on mica-schist, near Kiln Point on the coal grits, and elsewhere in the Horseshoe Estate on the brown sandstone overlying the limestone. This shows that the Eocene strata were deposited, consolidated, elevated, and denuded prior to the eruption of the basalt, which may have taken place in Upper Miocene or Pliocene times.

ROCK-PHOSPHATE.

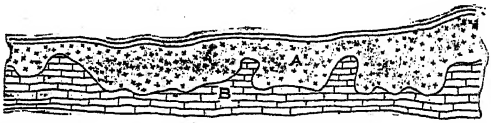
This was first found at Discovery Point, at the head of the bend, where it rests on the upper surface of the limestone. Here it forms a massive outcrop from 12 ft. to 18 ft. high and from 4 to 5 chains long. It consists of a very dense grey or yellowish-grey rock-phosphate, very rich in calcium phosphates. In places it is nearly pure phosphorite, occurring in narrow-banded pale-yellow and grey concretionary masses, possessing a tendency to exfoliate in layers when struck with a hammer. Cavities in this rock were found to be incrusted with apatite possessing a mammillary structure. The extent of the deposit at this place has not yet been determined.

Another outcrop of rock-phosphate crops out on the side of the valley opposite Discovery Point, and near it several large masses of this mineral occur in a small depression in the hill about 20 ft. above this outcrop. Recent excavations show that the phosphate-deposit here is of considerable extent. It has been exposed by open trenches for a distance of 4 chains along the side of the hill, and is found to rest on an eroded surface of the greensands. Loose masses of rock-phosphate, lying on the slopes to the north of this, point to the presence of another deposit in that direction.

At Kiln Point a considerable amount of stripping and trenching has been effected, and here much interesting information was obtained concerning the mode of occurrence of the rock-phosphate. At this place the outcrop has been stripped for a distance of nearly 2 chains, exposing a very clear vertical section of the phosphate-deposit and underlying limestone. The phosphate varies from 3 ft. to 12 ft. in thickness, and rests in a series of pockets in a deeply eroded surface of the limestone. In the face behind the old lime-kiln there are three shallow pockets, the most southerly being

45 ft. wide, the second 18 ft., and the third about 22 ft., varying in depth from 2 ft. to 6 ft. The pockets are separated from each other by ridges of limestone averaging 3 ft. or 4 ft. wide, as shown in the following diagram :—

SECTION I.



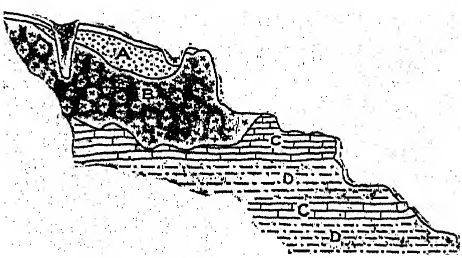
Kiln Point: Face exposed behind old kiln. A. Phosphate rock. B. Limestone.

The phosphate fills the pockets and rises above the level of the dividing-ridge of limestone to a height varying from 3 ft. to 10 ft., the greatest depth occurring at the north-east end of the section.

The phosphate rock exposed in the face of the open cutting is much broken and crushed, and sometimes shows slickenside surfaces. It is yellowish-brown in colour, with irregular seams and patches of whitish-grey. The presence of sand renders it soft and friable, and of lower grade than that exposed at Discovery Point.

At the most easterly point of the open cut masses of fairly pure phosphate rock contain inclusions of basalt, occurring in small angular or nodular fragments which are seldom over 4 in. in diameter. In a deep narrow trench above the open cutting the phosphate is mixed with glauconitic greensands which are said to be highly phosphatic.

SECTION II.



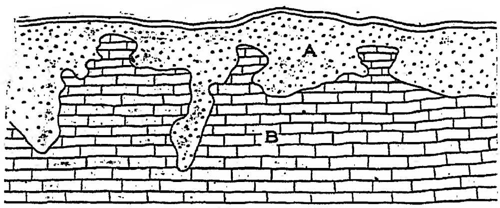
Kiln Point. A. Phosphatic greensands. B. Phosphate rock. C. Limestone. D. Glauconitic greensands.

The rock-phosphate has been exposed by a long trench some 12 chains north of Kiln Point, but no feature of special interest is disclosed in this direction.

At Millburn lime-quarry the surface of the Eocene lime-

stone presents the most marked irregularity. Under the influence of both chemical and physical erosion it has been formed into wide basins and deep well-like holes, surmounted by overhanging knobs and spires of limestone. The basins are filled with yellowish-brown sands, as shown in Section III. below.

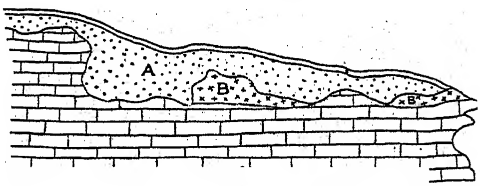
SECTION III.



Millburn Quarry, showing surface of limestone in present working-face. A. Brown sands. B. Limestone.

On the right side of the present quarry-face the upper horizon of limestone has been eroded down to the lower more sandy and glauconitic horizon, on the irregular surface of which there rest two small patches of rock-phosphate, as shown in Section IV.

SECTION IV.



Millburn Quarry, showing two patches of phosphate rock resting on lower horizon of limestone.

On the right bank of a small stream near Sutherland's limestone quarry there is a high face of rock-phosphate resting in a basin in the lower horizon of limestone, and a few hundred yards south-west of Millburn quarry there is a similar but smaller outcrop, which also appears to lie on the higher part of the lower horizon. The surface contours and the presence of basalt fragments in the phosphates at Kiln Point tend to show that the formation of the deposits took place in comparatively recent times—probably in the Post-Pliocene period—and, obviously, since the present contours of the district were determined. Hence it seems probable that the phosphate-deposits will be marginal, and follow the line of limestone outcrop, contouring around the slopes of the hills bounding the valleys and shallow basins.

ORIGIN OF ROCK-PHOSPHATE.

Rock-phosphate consists of tricalcium phosphate, which has the formula $Ca_3P_2O_5$. It is often called "bone-phosphate," because it is the substance of which bone is composed.

The bones of all vertebrate animals contain about 60 per cent. of tricalcium phosphate, while the excrement of some is also rich in the same substance.

Although invertebrates rarely contain phosphate of lime, there are some notable exceptions—namely, the Brachiopods *Lingula* and *Orbicula*, also *Conularia*, *Serpulites*, and some recent and fossil crustaceans. Hence deposits rich in phosphoric anhydride (P_2O_5) are found in rocks of all ages, from the Laurentian up to nearly the Recent period.

The formation of phosphate-deposits is generally believed to have been due to the leaching or lixiviation of phosphate-bearing rocks by waters containing carbonic and other organic acids, followed by the subsequent concentration of the phosphate under favourable conditions. In some cases they deposited their calcium phosphate in caverns formed in limestone or calcareous sandstone, and the subsequent removal by solution of the walls of the caverns, either wholly or partially, left the phosphate in the remaining sands.

It may be of some interest to note that the apatite beds and veins of Ottawa, in Canada, occur in rocks of Laurentian age. The brown rock-phosphate of Tennessee is believed to have been derived from the weathering of certain phosphatic layers in the Lower Silurian limestone which forms the basin of middle Tennessee. These layers do not occupy an unvarying stratigraphical position, but occur in various horizons in the Lower Silurian formation.*

The phosphate-deposits in the South of England, in France, and Belgium occur associated with Cretaceous chalk. Those of Algeria and Tunis are of Eocene age, the phosphates occurring in nodules in marl or as phosphatic limestone. In Algeria, which has been estimated by M. Chateau, a French mining engineer, to contain from 150,000,000 to 300,000,000 tons of phosphate rock, it is considered risky to mine rock under 60 per cent. of the tricalcic phosphate.†

The celebrated phosphate-deposits in Peninsular Florida occur in detached pockets in the uneven surfaces of an Eocene limestone, and in Western Florida on Miocene limestone, under geological conditions which seem almost the same as those existing on the Horseshoe Estate at Clarendon.

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* William Hayes, Annual Rept. U.S. Geol. Survey, 1898–99, p. 633.

† "Memoirs of the French Society of Civil Engineers," August, 1897.

The once-famous beds of South Carolina are considered to be of Post-Pliocene age.*

The phosphate of lime formerly worked at Aruba and Sombrero, in the West Indies, was originally a coral limestone converted into a phosphate by the percolation of water containing phosphoric acid derived from the overlying deposits of bird-guano.

The geological conditions which accompany and doubtless determine the presence of workable deposits of phosphate are the presence of a phosphate-bearing formation at the surface, lying in a favourable position for weathering and subsequent concentration of phosphate by replacement or secondary enrichment.

To favour the formation of large deposits it is further necessary that the topographical conditions should be such as to favour the weathering of the phosphatic beds over considerable areas. Should the phosphate-bearing bed, for example, crop out on a steep slope, the width of exposed surface where the weathering can take place will be necessarily limited in extent, the greater part of the formation being protected by the superincumbent strata. Hence phosphate-deposits left by leaching or produced by concentration on such steep slopes will be narrow, of small extent, and in a position easily removed by denudation.

On the other hand, where the phosphate-bearing rock is exposed on long gentle slopes, or over an extent of nearly level country, well drained by streams, the conditions will be favourable for the leaching of the rock over correspondingly wide areas, and consequently favour the formation of large deposits.

So far as known to the author, the discovery of workable deposits of phosphate of lime on the Horseshoe Estate at Clarendon is the first in Australasia, and, apart from its importance to the owners, is certain to prove of inestimable value to the agricultural interests of the colony.

The evidence available from a surface examination shows that a large quantity of phosphate rock exists in this district, but until the deposits have been fully developed by trenching it would obviously be impossible to express the tonnage numerically.

This discovery will doubtless be followed by other discoveries in different parts of the colony in districts where similar geological conditions exist, the most likely localities being in Southland, North and South Otago, North and South Canterbury, Marlborough, Raglan, and North Auckland dis-

* Penrose: U.S. Geol. Survey, Bulletin No. 46, 1898, p. 60.

trict. Phosphate-bearing rock is easily overlooked, as witness the deposits in Millburn quarry which lay exposed to the view of all passers for years. The purer phosphorite is often very compact, fine-grained, and hard, possessing also the banded, wavy, and chalcedonic structure characteristic of chert or flinty quartz deposited from thermal waters, for which it was long mistaken at Millburn.

The calcareous sandstone or limestone overlying and forming the closing member of the brown-coal measures is found very widely in both the North and South Islands, as already indicated; and whenever its surface is weathered and uneven the material filling the irregularities, whether it be hard rock or soft sandy marls, should be submitted to chemical examination for determination of phosphoric acid.

To become of commercial value a phosphate-deposit should fulfil the following requirements:—

(1.) Of such magnitude as to justify the erection of tramways and other surface plant necessary for development and winning of mineral.

(2.) Of high grade, averaging not less than 50 per cent. of tricalcic phosphate before dressing.

(3.) In a position easy of access to a railway or seaboard.

(4.) Easy to win—that is, in a position in which it can be worked water-free by open cuts and quarrying. The overburden must also be shallow and easily removed. When it exceeds 20 ft. the cost of stripping runs away with the profit.

It is only in exceptional cases that it pays to mine phosphate by underground workings. At Ross Farm, in Pennsylvania, during the year 1899, 2,000 long tons were mined from a stratum 30 ft. thick, 4,000 ft. long, and inclined at an angle of 60° from the horizontal. The stratum was mined to a depth of 300 ft. below water-level, and averaged about 56 per cent. of phosphate. Here the matrix consists of a yellow marl, very easily and cheaply broken. The producers, however, do not anticipate to be able to compete in distant markets with the higher grades of phosphate from South Carolina, Tennessee, and Florida, but look only for a remunerative local market.*

* 21st Annual Rept. U.S. Geol. Survey, 1899–1900, p. 494.

ART. XLIX.—*Notes on the Occurrence of Native Lead at Parapara, Collingwood.*

By Professor JAMES PARK, F.G.S., Director, Otago University School of Mines.

[*Read before the Otago Institute, 8th July, 1902.*]

DURING a geological survey of Collingwood County in 1887 I was informed by some miners of the occurrence of lead globules in the gold drifts in their claims, the quantity in some cases being said to be so great as to seriously interfere with the recovery of the gold on account of the ripples in the sluice-boxes becoming choked with the lead. The prevailing belief among the miners then, and now, was that the lead was ordinary shot, which had been used by sportsmen in the chase after native game in bygone days. This explanation seemed to me insufficient to account for the large quantities of lead obtained at the periodical "wash-up"; and in that year, at my request, Mr. H. P. Washbourn, of Parapara, forwarded a sample to the Geological Survey Department at Wellington for examination. The sample was submitted to the late Mr. William Skey, Government Analyst, who reported that it was native lead.

In a paper read before the Wellington Philosophical Society, Mr. Skey stated that the lead globules were coated with a thin incrustation of lead-carbonate, while some exhibited spangles of gold upon some surfaces. He added, "They have a great scientific interest, owing to the fact that the gold is in actual contact with the lead, often, indeed, actually surrounding it." The sample submitted to Mr. Skey was unfortunately very small, but, so far as it could be tested, he stated that the lead appeared to be unalloyed with any metal whatsoever.*

For some years past the Parapara Hydraulic and Sluicing Company (Limited), of London, has been carrying on operations at Parapara, principally in the old Glengyle and Hit or Miss alluvial claims. Mr. William Beetham, the local managing director, in the course of a conversation with me last February in Nelson, mentioned the trouble and extra labour often occasioned at the periodical "clean-up" by the presence of round shot-like globules of lead which collected in the ripples with the gold. The lead, he said, occurred in considerable quantities, and as an approximate estimate he thought about 25 lb. was obtained for every 100 oz. of

* Trans. and Proc. N.Z. Inst., 1888, vol. xxi., p. 368.

gold won by sluicing. Subsequently Mr. Beetham kindly handed me a sample for examination, weighing about 2 lb. The lead in this sample was very soft and malleable, and coated with a thin incrustation of lead-carbonate. It consisted principally of small irregular globules, varying from 0·1 cm. to 0·4 cm. in diameter, and flat thick plates varying from 0·25 cm. to 1·00 cm. long. Some of the latter weighed 10 gr., and of the former 5 gr. None of the globules of lead exhibited spangles of gold as reported by Mr. Skey, but several portions, weighing 200 gr. when cupelled, in every case showed the presence of both gold and silver, as under:—

	Gold. Grains.	Silver. Grains.
Round globules	0·005	0·01
Flat pieces	0·007	0·02

Careful chemical tests showed the lead was perfectly pure and unalloyed with metal of any kind. Arsenic and antimony were specially looked for without success.

The rocks in the neighbourhood of the Glengyle Claim are crystalline limestones, quartzites, mica-schist, and talc-schist of probably Lower Silurian age, associated with masses of gabbro, generally much altered. Glengyle Claim itself occupies a deep narrow gutter, which is believed by Sir James Hector, who made a detailed examination of the locality in 1890, to mark the course of a large fault or slide.* With such a variety of rocks it is impossible to determine which formed the original matrix of the lead.

Metallic lead is very subject to oxidation, and for this reason is rarely found in its native state. The authentic recorded instances of its occurrence are very few, and in no case is it abundant.

* Geol. Rep. and Explo., p. xii.

V.—CHEMISTRY AND PHYSICS.

ART. L.—*Notes on the Aurora in the Southern Hemisphere.*

By HENRY SKEY.

[Read before the Otago Institute, 8th July, 1902.]

THE advances which have been recently made by European observers in their endeavours to discover the "secret of the aurora" will, I trust, be considered as sufficient excuse for giving a special description of a peculiarity of appearance which the aurora sometimes exhibits in southern latitudes, more especially as this phenomenon in its completeness has not hitherto been described. The most brilliant display was witnessed on the 18th March, 1870, at Dunedin, New Zealand, at 8.30 p.m. From recorded observations at that time, arches of clear white light were first observed extending from east to west, and stretching like bands across the whole of the southern portion of the sky, the summit of the highest and largest arch being somewhat south of the zenith. This highest arch then appeared gradually to enlarge by moving in a lateral direction until it crossed over the zenith, when by continuing this motion it formed a lower arch on the northern side of the zenith. These arches were then observed to gradually increase in number until they formed symmetrical bands of light across the whole sky, the eastern and western points of the horizon forming as it were pivotal centres. This display lasted fully two hours; no coruscations were detected, the bands remaining perfectly steady with the exception of the slow lateral movement alluded to. The moon, which had a small halo round it, was near full at the time, and not far from the eastern extremity of the bands, but higher and more to the northward. The sky was free from clouds, and the air calm. On this occasion the ordinary characteristics of auroral light were entirely absent, there being no polar illumination nor coruscations radiating therefrom (but aurora was generally observed in New Zealand on the 12th, 18th, and 22nd, and in New South Wales on the 22nd).

It was otherwise, however, with the fine display of polar aurora which occurred on the 23rd November, 1870, when similar arches or bands of light were observed at the same

time over the whole sky, their terminations being in the same eastern and western portions of the horizon, and this simultaneously with a brilliant auroral light in the southern quarter. The sky at the same time was free from clouds, and the air calm. It is worthy of note that though on five out of six times on which these bands have been observed the moon was above the horizon, on this occasion it was invisible, as it was new moon on the 23rd. This circumstance removes some of the complexity which might otherwise arise in accounting for this phenomenon, lunar halos of any description being inadmissible.

A third display in the same year took place on the 13th May, the arches extending from east to west, a beautiful lunar halo occurring at the same time, the moon being not far from the northern quarter. The sky was slightly hazy, as only large stars were seen, and the air was calm.

Another display (and the earliest observed at this station) took place on the 10th July, 1867, and in this case the bands, instead of extending from east to west, stretched from north to south, and it was compared at the time to the streamers of an aurora australis meeting the streamers of aurora borealis. An apt comparison, and one which would perhaps illustrate the phenomenon more forcibly than a description, might be made by supposing these bands as they appeared on this occasion to represent a number of imaginary meridians at some uniform distance above the globe. A very fine lunar halo was seen at the same time, the moon being somewhat west of the meridian; the air was calm. Lunar halos were also seen at Sydney on the 8th, 9th, and 10th. A similar phenomenon occurred on the 29th March, 1869, in which the bands extended from north to south, accompanied by a lunar halo, the moon being near full and over the east.

I shall instance another case by making the following extracts from recorded meteorological observations. "On the 1st May, 1871, symmetrical bands of light seen at 9.45 p.m. similar to those of 1870. They had their terminations east and west; were very distinct; stars could be seen through them. They radiated so regularly from the east and west (fanlike) that a luminary might have been supposed to have been under the horizon at these points. On this occasion also the moon was near the meridian and surrounded by a large halo; the air was calm." "A partial display occurred on the 25th September, 1871, in the eastern quarter, seen in broad daylight, about 5.45 p.m. The radiations were straight, and spread, fanlike, for about 35° upward from the horizon. The edges of these bands were well defined, and not gradually shaded off. They were unmistakably distinct from, and not to be confounded with, light cirrus clouds which were also

observed covering part of the sky in streaks which roughly coincided with these bands."

It may be interesting to give Captain Cook's remarks on what was evidently a partial display of these luminous streamers adorning the night sky of the south. In the course of his second voyage he remarks that "on the 17th February, 1773, a beautiful phenomenon was observed in the heavens. It consisted of long colours of a clear white light shooting up from the horizon to the eastward almost to the zenith, and spreading *gradually* over the whole southern part of the sky. These columns sometimes bent sideways at their upper extremity, and though in most respects similar to the northern lights, yet differed from them in being always of a whitish colour. The stars were sometimes hid by, and sometimes faintly to be seen through, the substance of these southern lights. The sky was generally clear, the air sharp and cold, the ship being in latitude 58° south."

I shall instance another display occurring recently, on the evening of Sunday, the 28th of July, 1901, from my notes. "This evening the whole sky from 6.30 p.m to 9.30 p.m. was lit up with beautiful symmetrical bands of light, which appeared to radiate from the S.W. horizon, and after crossing the sky converged to the opposite or N.E. part of the horizon. The only motion observed was a slow lateral one of the whole bands towards the S.E. The moon (which was within three days off the full) was surrounded by a very distinct and perfect halo of 30° diameter, of the same white colour as the bands across the sky. The apparent convergence of these bands at their ends as they approach the horizon is possibly only the result of perspective. The sky was clear and the wind N.E.

"Observations as early as 1859 tended to connect solar energy with intense magnetic action. Moreover, brilliant auroral streamers were seen in both hemispheres on the night following the solar disturbance, proving that a relation exists between the aurora, terrestrial magnetism, and the central luminary of our system."

It is remarkable that auroras and halos often occur together or near the same time, indicating a similarity of electrical and atmospheric conditions as necessary for their production. The year 1870 was characterized by the frequency of these phenomena, and in the summary of sun-spot observations made at Kew the observers remark that "the year 1870 was characterized by an exuberance of solar energy which is without parallel since the beginning of observations in 1825."

I am enabled to give another instance of a daylight exhibition of these bands or arches, which occurred in the morning of the 11th October, 1901. On this occasion it was noticed

that a light and regular haze overspread the atmosphere, and the sun was observed lighting up the haze near the earth's surface through the rifts in the tree-tops, causing straight lines of light. This haze may be connected with the bright bands of light which later on, at 8.15 a.m., were observed radiating fanlike from the south part of the horizon and extending near to the zenith. The sun was east-north-east, shining right across the bands. The sky was generally clear excepting a few filmy cirrus clouds. The spaces between the bands were about the same breadth as the bands.

It may be observed that nature is generally in her calm and serener moods when these phenomena occur. It is to be regretted that no means were at hand to make spectroscopic or magnetic examinations of these streams of light, but this communication is intended as giving observations only, and may indicate a line of future research.

Art. LI.—*On the Construction of a Table of Natural Sines by Means of a New Relation between the Leading Differences.*

By C. E. Adams, B.Sc. (Honours), A.I.A., late Engineering Entrance Scholar and Engineering Exhibitioner, Canterbury College; late Senior Scholar in Physical Science, New Zealand University.

[*Read before the Wellington Philosophical Society, 18th November, 1902.*]

Part I.

The art of calculating tables of the numerical values of the trigonometrical ratios seems to have fallen into disuse for over a century, as the greater portion of this work was done in the seventeenth and eighteenth centuries, and modern tables are in almost every instance but reprints of the earlier ones.

It appears from the report of the British Association for Advancement of Science, 1873, on mathematical tables, that the most extensive table of natural sines is that given by François Callet in his "Tables Portatives de Logarithmes," Paris, 1795 (Tirage, 1860). In this work the natural sines are given to fifteen places of decimals for every 0·001 of the quadrant—that is, for every 5′ 24″. In the introduction the process of calculating the table is described, and from it the following summary and extracts are made.

Expanding the cosine and sine by Maclaurin's theorem, we have the usual series,—

$$\cos z = 1 - \frac{z^2}{2\,!} + \frac{z^4}{4\,!} - \frac{z^6}{6\,!} + \frac{z^8}{8\,!} - \&c.$$

$$\sin z = z - \frac{z^3}{3\,!} + \frac{z^5}{5\,!} - \frac{z^7}{7\,!} + \frac{z^9}{9\,!} - \&c.$$

where z is expressed in radians.

These series are not in convenient form for numerical calculation, so put $z = \frac{m}{n} \cdot \frac{\pi}{2}$

then $\cos z = 1 - \frac{m^2}{n^2} \cdot \frac{1}{2\,!}\left(\frac{\pi}{2}\right)^2 + \frac{m^4}{n^4} \cdot \frac{1}{4\,!}\left(\frac{\pi}{2}\right)^4 - \frac{m^6}{n^6} \cdot \frac{1}{6\,!}\left(\frac{\pi}{2}\right)^6 + \&c.$

and $\sin z = \frac{m}{n} \cdot \frac{\pi}{2} - \frac{m^3}{n^3} \cdot \frac{1}{3\,!}\left(\frac{\pi}{2}\right)^3 + \frac{m^5}{n^5} \cdot \frac{1}{5\,!}\left(\frac{\pi}{2}\right)^5 - \&c.$

For convenience these may be written

$$\cos z = 1 - \frac{m^2}{n^2} \cdot A + \frac{m^4}{n^4} \cdot B - \frac{m^6}{n^6} \cdot C + \frac{m^8}{n^8} \cdot D - \&c. \quad (P)$$

$$\text{and } \sin z = \frac{m}{n} \cdot a - \frac{m^3}{n^3} \cdot b + \frac{m^5}{n^5} \cdot c - \frac{m^7}{n^7} \cdot d + \&c. \quad (Q)$$

where (Callet, pages 27 and 28)—

$$A = \frac{1}{2\,!} \cdot \left(\frac{\pi}{2}\right)^2 = 1\cdot 23370,\ 05501,\ 36169,\ 82735,\ 43$$

$$B = \frac{1}{4\,!} \cdot \left(\frac{\pi}{2}\right)^4 = 0\cdot 25366,\ 95079,\ 01048,\ 01363,\ 66$$

$$C = \frac{1}{6\,!} \cdot \left(\frac{\pi}{2}\right)^6 = 0\cdot 02086,\ 34807,\ 63352,\ 96087,\ 31$$

$$D = \frac{1}{8\,!} \cdot \left(\frac{\pi}{2}\right)^8 = 0\cdot 00091,\ 92602,\ 74839,\ 42658,\ 02$$

$$E = \frac{1}{10\,!} \cdot \left(\frac{\pi}{2}\right)^{10} = 0\cdot 00002,\ 52020,\ 42373,\ 06060,\ 55$$

$$F = \frac{1}{12\,!} \cdot \left(\frac{\pi}{2}\right)^{12} = 0\cdot 00000,\ 04710,\ 87477,\ 88181,\ 72$$

$$G = \frac{1}{14\,!} \cdot \left(\frac{\pi}{2}\right)^{14} = 0\cdot 00000,\ 00063,\ 86603,\ 08379,\ 19$$

$$H = \frac{1}{16\,!} \cdot \left(\frac{\pi}{2}\right)^{16} = 0\cdot 00000,\ 00000,\ 65659,\ 63114,\ 98$$

$$I = \frac{1}{18\,!} \cdot \left(\frac{\pi}{2}\right)^{18} = 0\cdot 00000,\ 00000,\ 00529,\ 44002,\ 01$$

$$J = \frac{1}{20\,!} \cdot \left(\frac{\pi}{2}\right)^{20} = 0\cdot 00000,\ 00000,\ 00003,\ 43773,\ 92$$

$$K = \frac{1}{22\,!} \cdot \left(\frac{\pi}{2}\right)^{22} = 0\cdot 00000,\ 00000,\ 00000,\ 01835,\ 99$$

$$L = \frac{1}{24\,!} \cdot \left(\frac{\pi}{2}\right)^{24} = 0\cdot 00000,\ 00000,\ 00000,\ 00008,\ 21$$

$$M = \frac{1}{26\,!} \cdot \left(\frac{\pi}{2}\right)^{26} = 0\cdot 00000,\ 00000,\ 00000,\ 00000,\ 03$$

&c., and

$$a = \frac{\pi}{2} \qquad\qquad = 1\cdot57079,\ 63267,\ 94896,\ 61923,\ 13$$
$$b = \frac{1}{3\,!} \cdot \left(\frac{\pi}{2}\right)^3 = 0\cdot64596,\ 40975,\ 06246,\ 25365,\ 58$$
$$c = \frac{1}{5\,!} \cdot \left(\frac{\pi}{2}\right)^5 = 0\cdot07969,\ 26262,\ 46167,\ 04512,\ 05$$
$$d = \frac{1}{7\,!} \cdot \left(\frac{\pi}{2}\right)^7 = 0\cdot00468,\ 17541,\ 35318,\ 68810,\ 07$$
$$e = \frac{1}{9\,!} \cdot \left(\frac{\pi}{2}\right)^9 = 0\cdot00016,\ 04411,\ 84787,\ 35982,\ 19$$
$$f = \frac{1}{11\,!} \cdot \left(\frac{\pi}{2}\right)^{11} = 0\cdot00000,\ 35988,\ 43235,\ 21208,\ 53$$
$$g = \frac{1}{13\,!} \cdot \left(\frac{\pi}{2}\right)^{13} = 0\cdot00000,\ 00569,\ 21729,\ 21967,\ 93$$
$$h = \frac{1}{15\,!} \cdot \left(\frac{\pi}{2}\right)^{15} = 0\cdot00000,\ 00006,\ 68803,\ 51098,\ 11$$
$$i = \frac{1}{17\,!} \cdot \left(\frac{\pi}{2}\right)^{17} = 0\cdot00000,\ 00000,\ 06066,\ 93573,\ 11$$
$$j = \frac{1}{19\,!} \cdot \left(\frac{\pi}{2}\right)^{19} = 0\cdot00000,\ 00000,\ 00043,\ 77065,\ 47$$
$$k = \frac{1}{21\,!} \cdot \left(\frac{\pi}{2}\right)^{21} = 0\cdot00000,\ 00000,\ 00000,\ 25714,\ 23$$
$$l = \frac{1}{23\,!} \cdot \left(\frac{\pi}{2}\right)^{23} = 0\cdot00000,\ 00000,\ 00000,\ 00125,\ 39$$
$$m = \frac{1}{25\,!} \cdot \left(\frac{\pi}{2}\right)^{25} = 0\cdot00000,\ 00000,\ 00000,\ 00000,\ 52,\ \&c.$$

By means of these formulæ the sines and cosines of angles are readily obtained: and the calculation of the leading differences for the formation of a table of natural sines is described by Callet thus:—

"S'il est question de trouver les sinus d'une suite d'arcs en progression arithmétique; on peut à l'aide du calcul des différences finies; tirer des formules précédentes, d'autres formules qui donnent les différences premieres, secondes, troisiemes, &c., de ces quantités: pour cela, reprenons la formule Q

$$\sin\frac{m}{n}\cdot\frac{\pi}{2} = \frac{m}{n}\cdot a - \frac{m^3}{n^3}\cdot b + \frac{m^5}{n^5}\cdot c - \frac{m^7}{n^7}\cdot d + \&c.$$

Substituons, dans cette équation Q, $m + \Delta m$ à m; il viendra une équation Q^1 de laquelle ôtant l'équation Q, nous aurons

$$\Delta \sin \frac{m}{n} \cdot \frac{\pi}{2} - \frac{a\cdot\Delta m}{n}$$
$$- \frac{b\cdot\Delta m}{n^3}\,(3m^2 + 3m\Delta m + \Delta m^2)$$
$$+ \frac{c\cdot\Delta m}{n^5}\,(5m^4 + 10m^3\Delta m + 10m^2\Delta m^2 + 5m\Delta m^3 + \Delta m^4)$$

$$- \frac{d \cdot \Delta m}{n^7}(7m^6 + 21m^5\Delta m + 35m^4\Delta m^2 + 35m^3\Delta m^3 + \&c.)$$

$$+ \frac{e \cdot \Delta m}{n^9}(9m^8 + 36m^7\Delta m + 84m^6\Delta m^2 + \&c.)$$

$$- \frac{f \cdot \Delta m}{n^{11}}(11m^{10} + 55m^9\Delta m + \&c.)$$

$$+ \frac{g \cdot \Delta m}{n^{13}}(13m^{12} + \&c.) - \&c. \qquad (\Delta Q)$$

"Nous trouverons de même en faisant Δm constant

$$\Delta^2 \sin \frac{m}{n} \cdot \frac{\pi}{2} = - \frac{b \cdot \Delta m^2}{n^3}(6m + 6\Delta m)$$

$$+ \frac{c \,.\, \Delta m^2}{n^5}(20m^3 + 60m^2\Delta m + 70m\Delta m^2 + 30\Delta m^3)$$

$$- \frac{d \cdot \Delta m^2}{n^7}(42m^5 + 210m^4\Delta m + 490m^3\Delta m^2 + 630m^2\Delta m^3 + 434m \cdot \Delta m^4 + 126\Delta m^5)$$

$$+ \frac{e \cdot \Delta m^2}{n^9}(72m^7 + 504m^6\,\Delta m + 1764m^5\,\Delta m^2 + 3780m^4\Delta m^3 + \&c.)$$

$$- \frac{f \cdot \Delta m^2}{n^{11}}(110m^9 + 990m^8\,\Delta m + 4620m^7\,\Delta m^2 + \&c.)$$

$$+ \frac{g \cdot \Delta m^2}{n^{13}}(156m^{11} + 1716m^{10}\,\Delta m + \&c.)$$

$$- \frac{h \cdot \Delta m^2}{n^{15}}(210m^{13} + \&c.) + \&c. \qquad (\Delta^2 Q)$$

$$\Delta^3 \sin \frac{m}{n} \cdot \frac{\pi}{2} = - \frac{6b \cdot \Delta m^3}{n^3} + \frac{c \cdot \Delta m^3}{n^5}(60m^2 + 180m\Delta m + 150\Delta m^2)$$

$$- \frac{d \cdot \Delta m^3}{n^7}(210m^4 + 1260m^3\Delta m + 3150m^2\Delta m^2 + 3780m\Delta m^3 + 1806\,\Delta m^4)$$

$$+ \frac{e \cdot \Delta m^3}{n^9}(504m^6 + 4536m^5\Delta m + 18900m^4\Delta m^2 + 45360m^3\Delta m^3 + \&c.)$$

$$- \frac{f \cdot \Delta m^3}{n^{11}}(990m^8 + 11880m^7\Delta m + 69300m^6\Delta m^2 + \&c.)$$

$$+ \frac{g \cdot \Delta m^3}{n^{13}}(1716m^{10} + 25740m^9\Delta m + 193050\,m^8\,\Delta m^2 + \&c.)$$

$$- \frac{h \cdot \Delta m^3}{n^{15}}(2730m^{12} + 49140m^{11}\Delta m + \&c.) + \&c. \quad (\Delta^3 Q)$$

$$\Delta^4 \sin \frac{m}{n}\,\frac{\pi}{2} = \frac{c \cdot \Delta m^4}{n^5}(120m + 240\Delta m)$$

$$- \frac{d \cdot \Delta m^4}{n^7}(840m^3 + 5040m^2\Delta m + 10920m\Delta m^2 + 8400\Delta m^3)$$

$$+ \frac{e \cdot \Delta m^4}{n^9}(3024m^5 + 30240m^4\Delta m + 131040m^3\Delta m^2 + \&c.)$$

$$- \frac{f \cdot \Delta m^4}{n^{11}}(7920m^7 + 110880m^6\Delta m + \&c.)$$
$$+ \frac{g \cdot \Delta m^4}{n^{13}}(17160m^9 + 308880m^8\Delta m + \&c.)$$
$$- \frac{h \cdot \Delta m^4}{n^{15}}(32760m^{11} + \&c.) + \&c. \qquad (\Delta^4 Q)$$

$$\Delta^5 \sin\frac{m}{n}\frac{\pi}{2} = \frac{120c \cdot \Delta m^5}{n^5} - \frac{d \cdot \Delta m^5}{n^7}(2520m^2 + 12600m\Delta m + 16800\Delta m^2)$$
$$+ \frac{e \cdot \Delta m^5}{n^9}(15120m^4 + 151200m^3\Delta m + 604800m^2\Delta m^2 + \&c.)$$
$$- \frac{f \cdot \Delta m^5}{n^{11}}(55440m^6 + 831600m^5\Delta m + 5544000m^4\Delta m^2 + \&c.)$$
$$+ \frac{g \cdot \Delta m^5}{n^{13}}(154440m^8 + 3088800m^7\Delta m + \&c.)$$
$$- \frac{h \cdot \Delta m^5}{n^{15}}(360360m^{10} + \&c.) + \&c. \qquad (\Delta^5 Q)$$

$$\Delta^6 \sin\frac{m}{n}\frac{\pi}{2} = - \frac{d \cdot \Delta m^6}{n^7}(5040m + 15120\Delta m)$$
$$+ \frac{e \cdot \Delta m^6}{n^9}(60480m^3 + 544320m^2\Delta m + 1723680m\Delta m^2 + 1905120\Delta m^3)$$
$$- \frac{f \cdot \Delta m^6}{n^{11}}(332640m^5 + 4989600m^4\Delta m + 31600800m^3\Delta m^2 + \&c.)$$
$$+ \frac{g \cdot \Delta m^6}{n^{13}}(1235520m^7 + 25945920m^6\Delta m + \&c.)$$
$$- \frac{h \cdot \Delta m^6}{n^{15}}(3603600m^9 + \&c.) + \&c. \qquad (\Delta^6 Q)$$

Ainsi des autres. Nota.—Ces expressions Δm^2, Δm^3, &c., tiennent lieu de celles-ci $(\Delta m)^2$, $(\Delta m)^3$, &c." (Callet, pages 59 and 60.)

Other expressions for the differences of $\sin x$ are, if $\Delta x = 2\theta$, as shown below,—

$$\Delta^{4n} \sin x = 2^{4n} \sin (x + 4n\theta) \sin^{4n}\theta$$
$$\Delta^{4n+1} \sin x = 2^{4n+1} \cos (x + \overline{4n+1}\,\theta) \sin^{4n+1}\theta$$
$$\Delta^{4n+2} \sin x = - 2^{4n+2} \sin (x + \overline{4n+2}\,\theta) \sin^{4n+2}\theta$$
$$\Delta^{4n+3} \sin x = - 2^{4n+3} \cos (x + \overline{4n+3}\,\theta) \sin^{4n+3}\theta$$

(De Morgan, "Differential and Integral Calculus.")

These four expressions may be combined into one expression as follows (Boole, "Finite Differences"):—

$$\Delta^m \sin x = 2^m \sin\left[x + m\left(\frac{\pi}{2} + \theta\right)\right] \sin^m\theta$$

Now, Colenso ("Plane Trigonometry") shows that when the tabular interval is small it is possible to use the expression

$\Delta^2 \sin x = -2^2 \sin (x + 2\theta) \sin^2\theta$ with advantage in the calculation of a table of natural sines.

It appeared that this relation between the sines and their second differences might be a general one, and upon investigation this was found to be the case, the general relation

$$\Delta^m \sin x = -2^2 \Delta^{m-2} \sin (x + 2\theta) \cdot \sin^2\theta \qquad \text{(A)}$$

being obtained.

This will now be proved; thus we have

$$\Delta^m \sin x = 2^m \sin \left[x + m \left(\frac{\pi}{2} + \theta\right)\right] \sin^m\theta$$

and similarly

$$\Delta^{m-2} \sin (x+2\theta) = 2^{m-2} \sin\left[x+2\theta+\left(m-2\right)\left(\frac{\pi}{2}+\theta\right)\right]\sin^{m-2}\theta$$

$$= 2^{m-2} \sin\left[x + m\left(\frac{\pi}{2} + \theta\right) - \pi\right] \sin^{m-2}\theta$$

$$= -2^{m-2} \sin\left[x + m\left(\frac{\pi}{2} + \theta\right)\right] \sin^{m-2}\theta$$

hence $\Delta^m \sin x = -2^2 \Delta^{m-2} \sin (x + 2\theta) . \sin^2\theta$

It will now be shown how it is possible by means of this relation to calculate readily the leading differences, and thus dispense with the cumbersome series for these differences given above by Callet.

For convenience (A) is preferably written

$$\Delta^m \sin x = -2 (1 - \cos 2\theta) \Delta^{m-2} \sin (x + 2\theta)$$

or $\Delta^m \sin x = -2 (1 - \cos \Delta x) \Delta^{m-2} \sin (x + \Delta x)$

or $\Delta^m \sin x = -k \cdot \Delta^{m-2} \sin (x + \Delta x) \qquad (A_1)$

where $k = 2 (1 - \cos \Delta x)$ and is a constant depending on the tabular interval only.

$$\text{Now, } \Delta^m \sin x = -k \cdot \left[\Delta^{m-2} \sin x + \Delta^{m-1} \sin x\right] \qquad (A_2)$$

hence any difference is expressed in terms of the two preceding differences.

The formation of the leading differences then reduces to the very simple operation shown in (A_2) above. It will only be necessary to compare this with the series given above (ΔQ, $\Delta^2 Q$, &c.) to see how much simpler the method here described is.

In Part II. the application of this method to the calculation of a table of natural sines will be given.

Art. LII.—*Two Spherical Harmonic Relations.*

By C. Coleridge Farr, D.Sc.

[*Read before the Philosophical Institute of Canterbury, 3rd September, 1902.*]

The relations proved in this paper were given without distinct proof as following simply from the generalised form of four others which I discovered in working out the expressions* for the intensity of the magnetic force in the interior of coils of various lengths. They were, however, cut out by Professor Lamb, who very kindly communicated my paper to the Royal Society, as he did not see how they were obtained. This of itself causes me to think they may be new, and, as the original four are, I believe, new ones, hope in this direction is strengthened. I have known them for some years now, but as they follow simply from the four already published I had not up till now thought them worth publication. I have, however, been recently rather strongly advised to print them.

Using the notation of my previous paper, the original four are these :—

$$(1) \qquad \frac{d}{dx}\frac{P_\sigma}{r^{\sigma+1}} = \frac{1}{r^{\sigma+2}}\frac{d}{d\theta}P_{\sigma+1}$$

$$(2) \qquad \frac{d}{dx}r^\sigma P_\sigma = r^{\sigma-1}\frac{d}{d\theta}P_{\sigma-1}$$

$$(3) \qquad \frac{d^i}{dz^i}\frac{P_\sigma}{r^{\sigma+1}} = \frac{(\sigma+i)!}{\sigma!}\frac{P_{\sigma+i}}{r^{\sigma+i+1}}$$

$$(4) \qquad \frac{d^i}{dz^i}r^\sigma P_\sigma = (-1)^i\frac{\sigma!}{(\sigma-i)!}r^{\sigma-i}P_{\sigma-i}$$

Now, since the order of differentiation is indifferent, we have

$$\frac{d^i}{dz^i}\frac{d}{dx}\frac{P_\sigma}{r^{\sigma+1}} = \frac{d}{dx}\frac{d^i}{dz^i}\frac{P_\sigma}{r^{\sigma+1}} \qquad (5)$$

Taking first the left-hand side of the equation and making use of (1) we have

$$\frac{d^i}{dz^i}\frac{d}{dx}\frac{P_\sigma}{r^{\sigma+1}} = \frac{d^i}{dz^i}\frac{1}{r^{\sigma+2}}\frac{d}{d\theta}P_{\sigma+1} \qquad (6)$$

Now, taking the right-hand side of (5) and using (3), it follows

$$\frac{d}{dx}\frac{d^i}{dz^i}\frac{P_\sigma}{r^{\sigma+1}} = \frac{d}{dx}\frac{(\sigma+i)!}{\sigma!}\frac{P_{\sigma+i}}{r^{\sigma+i+1}}$$

$$(\sigma+i)!\ \frac{1}{r^{\sigma+i+2}}\frac{d}{d\theta}P_{\sigma+i+1}$$

* Roy. Soc. Proc., vol. lxiv., p. 193.

from (1). Hence

$$\frac{d^i}{dz^i}\frac{1}{r^{\sigma+2}}\frac{d}{d\theta}\,\mathrm{P}\sigma+1=\frac{1}{r^{\sigma+i+2}}\,\frac{(\sigma+1)\,!}{\sigma\,!}\,\frac{d}{d\theta}\,\mathrm{P}\sigma+i+1$$

or, elevating one order,

$$\frac{d^i}{dz^i}\left(\frac{1}{r^{\sigma+1}}\frac{d}{d\theta}\,\mathrm{P}\sigma\right)=\frac{1}{r^{\sigma+i+1}}\,\frac{\sigma\,!}{(\sigma-1)\,!}\,\frac{d}{d\theta}\,\mathrm{P}\sigma+i \qquad (a)$$

which is the first of the two relations.

The second is established in a precisely similar manner. Thus

$$\frac{d}{dx}\frac{d^i}{dz^i}\,r^\sigma\,\mathrm{P}\sigma=\frac{d^i}{dz^i}\frac{d}{dx}\,r^\sigma\,\mathrm{P}\sigma$$

By means of (4) the left-hand side becomes

$$\frac{d}{dx}\frac{d^i}{dz^i}\,r^\sigma\,\mathrm{P}\sigma=(-1)^i\,\frac{d}{dx}\,\frac{\sigma\,!}{(\sigma-i)\,!}\,r^{\sigma-i}\,\mathrm{P}\sigma-i$$

$$=(-1)^i\,\frac{\sigma\,!}{(\sigma-i)\,!}\,r^{\sigma-i-1}\,\frac{d}{d\theta}\,\mathrm{P}\sigma-i-1$$

from (2). For the right-hand side we have, using (2),

$$\frac{d^i}{dz^i}\frac{d}{dx}\,r^\sigma\,\mathrm{P}\sigma=\frac{d^i}{dz^i}\left(r^{\sigma-1}\,\frac{d}{d\theta}\,\mathrm{P}\sigma-1\right)$$

Hence

$$\frac{d^i}{dz^i}\left(r^{\sigma-1}\,\frac{d}{d\theta}\,\mathrm{P}\sigma-1\right)=(-1)^i\,\frac{\sigma\,!}{(\sigma-i)\,!}\,r^{\sigma-i-1}\,\frac{d}{d\theta}\,\mathrm{P}\sigma-i-1$$

or, elevating one order,

$$\frac{d^i}{dz^i}\left(r^\sigma\,\frac{d}{d\theta}\,\mathrm{P}\sigma\right)=(-1)^i\,\frac{(\sigma+1)\,!}{\sigma\,!}\,r^{\sigma-i}\,\frac{d}{d\theta}\,\mathrm{P}\sigma-i$$

which is the second relation.

ART. LIII.—*On the Interpretation of Milne Earthquake Diagram.*

By C. COLERIDGE FARR, D.Sc.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

Plate L.

THE question as to whether a horizontal pendulum seismograph acts as a clinograph, or whether its records must in part be ascribed to horizontal movement of the earth's surface, has received discussion by Milne,* Ōmori,† and others, whose

* *Nature*, vol. lxv., p. 202, and B.A. Reports.

† Publications of the Earthquakes Investigation Committee, No. 5, Tokyo, 1900, p. 45 *et seq.*

arguments I have not been able to peruse. But Professor Milne and Dr. Ōmori conclude that the tilts represented by the maximum displacement of the boom are too large to be admissible as tilts; and Ōmori discusses the accelerations of the earth-particles of four earthquakes which would result from the assumption that the maximum boom-movement was due to a series of waves of vertical displacement passing under the pillar of the instrument.

The following considerations do not appear to me to have been sufficiently realised:—

The differential equation representing the motion of a body capable of free vibration of frequency n, but acted upon by a periodic force E cos pt, as

$$\frac{d^2u}{dt^2} + K\frac{du}{dt} + n^2 u = E \cos pt \quad *$$

where K is the constant of delay in the free vibration.

The solution of this is

$$u = \frac{E}{\sqrt{(n^2 - p^2)^2 + K^2 p^2}} \cos (pt - c)$$

where $\tan C = \frac{pK}{n^2 - p^2}$

This equation applies to seismograph of the Milne type and bodies also, as well as to other vibrating bodies.

The result shows (1) that the vibrating body, in this case the boom of a seismograph, no longer vibrates in its natural period $\frac{2\pi}{n}$, but takes the frequency of the disturbing force p; (2) that if friction be small compared with the difference of the squares of the frequencies, the resulting vibration has an amplitude $\frac{E}{n^2 - p^2}$; (3) the phenomenon of beats may occur between the forced vibration and the free period of the boom.

Considering the second conclusion first, it is evident that the maximum amplitude of swing of the boom gives no information whatever of the amplitude of the disturbing cause, without also a knowledge of the periods of the free and forced vibrations. It does not follow, as appears to be supposed, that the maximum amplitude of swing of the boom is associated with the maximum amplitude of the disturbing cause. Of waves of equal amplitude but different wave-lengths those nearest in period to the free period will give the largest trace, and if p and n become equal the only thing which prevents the swinging of the boom from eventually becoming infinite is the term K^2p^2, which in this case must be considered, though it is very often small enough to be neg-

* Rayleigh's "Sound," p. 38, 1st ed.

lected in other cases. It is thus quite an erroneous proceeding to take the most marked phase of an earthquake diagram and to assume that this corresponds to the waves of largest amplitude in the earth; and it is also quite erroneous to derive the amplitude of the earth-wave by multiplying the amplitude of the trace by the conversion factor from millimeters to seconds of arc. Regard must be paid to the period of the earth-wave and of the free boom-vibration. In the tabulation of records of Milne seismographs no regard is at present paid to the period of the earth-wave, and hardly more to the period of free boom-vibration, and no information is supplied of the value of the constant K, which, though often negligible (*i.e.*, when p and n are not very nearly equal), is occasionally of paramount importance. This constant can be deduced from the fact that the free vibration dies away according to an expression of the form

$$u = Ae^{-\frac{1}{2}kt} \cos \theta$$

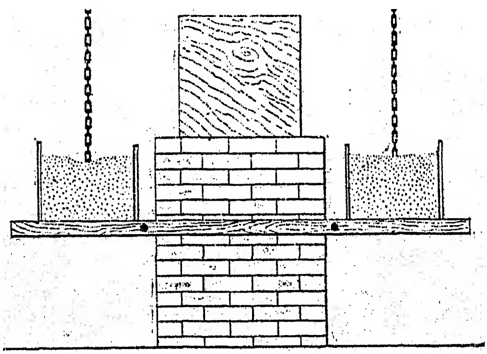
Turning now to the result (1), that the forced vibration takes place in the period of the disturbing cause, this enables us to derive a value both of the periods and wave-lengths of the various sets of waves acting on the boom; and the record is thus capable of supplying the information absolutely essential for the correct valuation of the amplitude E of the disturbing cause, from which can be easily derived the total movements and accelerations of the earth-particles at any phase of the earthquake. But to do this the tape must be driven at a much higher rate than is at present the case. It is difficult to see the individual vibration, and it is impossible to estimate the time of vibration to within an accuracy of a second, as is certainly necessary for the correct determination of E, with the tape moving at the rate of only 1 mm. per minute.

The phenomenon of interference I have many examples of in earthquakes I have recorded; and what Professor Milne* describes as "earthquake echoes" may be explained in this way, combined very often with increasing or decreasing amplitude of the disturbing cause.

To give ocular demonstration of the truth of these theoretical conclusions, I decided to attempt to imitate a series of waves acting on the pillar, and of known period. For this purpose I had two boxes attached, one to the east and the other to the west of the pillar, and in these I placed sawdust. Depending from the roof-ceiling of the room, by a rope passing over two pulleys fixed vertically above the centres of the two boxes, were two chains. The length of the rope was such that the two chains just touched the two beds of sawdust together. By pulling these chains up and down at definite

* B.A. Reports, 1899, p. 288.

rates a periodic tilting of the pillar, due to the loading of one side or the other by its proper chain and by more or less of it, was obtained bearing some resemblance to a sine curve, and of known period. Owing to an error of cutting the chains they were not of equal weight, one being 17½ lb. and the other 21 lb.,* but as in any case the resemblance to a sine curve was only a rough one, and as also the lighter chain acted upon the pillar at a somewhat greater area than the other, it was not considered worth while to alter it.



On removing one chain from its box and placing the other in its proper box the total boom-movement was 1·6 mm. I then proceeded to imitate in succession waves of 12 sec., 13 sec., 14 sec., 15 sec., 16 sec., 17 sec., 18 sec., 19 sec., and 20 sec. period, whilst the boom period throughout remained as nearly as I could determine at 16·5 sec. Before doing so I had increased the speed of the tape to 82 mm. per hour, so that the time-scale might be sufficiently open to enable me to count the individual vibrations of the boom. The various artificial seismograms thus obtained are appended. (Plate L.)

* I am indebted to the kindness of Messrs. E. Reece and Sons, of Christchurch, not only for lending me the chains, but for very courteously cutting lengths suitable for the purpose I had in view.

In every case conclusion 1—viz., that the boom no longer vibrates in its natural free period, but adopts the period of the forcing cause—is exactly verified. The amplitude of the resulting swings is in every case larger than that of the static displacement of $\frac{1\cdot 6}{2}$ mm., as with the period it theoretically should be, and as the synchronism becomes more perfect the boom-swing becomes larger; but I want to emphasize that, whatever has been the period of the forcing cause within the limits adopted, synchronism more or less complete is apparent. In no case, however, is the swing of the boom so great as it theoretically should be, supposing E to be 0·8 mm. This may be in part due to the imperfect imitation of a sine curve which resulted from the arrangement adopted, and there is no reason to conclude that because the tilt of the pillar due to the static alteration of a given disposal of weight is E, the displacement of the pillar due to a periodic alteration of this disposal will also be E.

Interference effects are seen in most of the artificial seismograms. Where they are absent the periods are so close that the free vibration has been damped down to comparative insignificance before opposition of place would occur. It appears to be probable, although the period of free vibration was determined as 16·5 sec., that its accurate value was more nearly 16·6 sec. It is difficult to determine the quantity accurately to 0·1 sec., and yet the result shows that it is important to do so.

As a result of this examination it appears—(1) that strict attention should be paid to accurately recording the period of free vibration; (2) that the tape should be driven at such a speed as will enable the period of forced vibration to be determined; (3) that the value of the constant K should be recorded.

We might then hope, by determining the amplitude of the earth-movement of any particular waves of given wave-length at different stations, to ascertain the law which governed the decrease of intensity with distance, and to determine how the velocity of the waves varied with their length.

As I am unacquainted with the practical details of Dr. Ōmori's instrument I have refrained from discussing the acceleration of the earth-particles given by him for certain earthquakes;* but if the considerations above set forth apply to his instrument, and if also they have been omitted in arriving at the results he gives, then by taking them into account the values of the accelerations would be so much reduced that it is improbable we should have felt the earthquakes he discusses.

* Publication of the Earthquakes Investigation Committee, No. 5, Tokyo, 1901, p. 45 *et seq.*

Art. LIV.—*On the Use of the Standard Functions in Interpolation.*

By E. G. Brown.

[*Read before the Wellington Philosophical Society, 16th December, 1902.*]

There is a parallel between the expression of functions by Taylor's Series expansion formulæ, and of tables of numbers by interpolation formulæ, depending on finite differences. In both cases there is usually a "remainder" which is neglected as being immaterial. This parallel is seen to be very close if closely examined; but we need here only remark that, just as we have found it possible to reduce the degree of many Taylor's Series expansions by means of the standard functions,* so also it is possible to reduce the number of differences required to interpolate in a normal table of figures. This, again, is a matter into which we need not go; defining the problem in hand as follows: Given a table of numbers, and having differenced them, what is the best formula—or, in other words, the formula of the least number of terms—that can be found to perform the interpolation by finite differences between two consecutive values of the numbers, the arguments being, of course, at equal intervals?

There are a number of ways of deducing formulæ of interpolation, the chief of which result in what are called† Newton's, Lagrange's, and Bessel's methods, the latter being generally employed when more than two differences are significant. Each of these methods gives rise to a series of functions analogous to the standard functions, and in cases identical with them. Thus, in all cases the first function is the linear (L), and the second the standard parabola, $x(1-x)$. In Newton's and Lagrange's methods the other formulæ are not the same, but diverge widely from the standard form—less widely in Lagrange's method than in Newton's. Bessel's method, however, brings in the standard cubic and then diverges from the standard form.

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* Trans. N.Z. Inst., 1901, p. 519 *et seq.*

† This nomenclature is drawn from that of F. G. Gauss (5-fig. Log. and Trig. Tables, larger edition, 1900, p. 150), who gives Lagrange's and Newton's methods for unequal increments, and then says, "Bei gleichen Intervallen gehen diese Formeln in die Formeln (1) und (2) über," *i.e.*, into the methods referred to (Bessel's being, of course, a modification of Lagrange's method).

There is no doubt that Newton's method is in general inferior to either of the others. This arises from two facts: (1) the differences are so chosen as to depend on the values following the interval, instead of on those of both sides of it, and (2) the terms do not converge so rapidly as in the other forms. We shall therefore not develope Newton's method here, since in practical problems it is generally possible to give the values on each side of the interval.

Lagrange's and Bessel's methods employ the same differences—those indicated by the dotted line in the following table:—

$$
\begin{array}{llllllll}
 & Y_{-3} & & & & & & \\
 & & \Delta^1 & & & & & \\
 & Y_{-2} & & \Delta^2 & & & & \\
 & & \Delta^1 & & \Delta^3 & & & \\
 & Y_{-1} & & \Delta^2 & & \Delta^4 & & \\
 & & \Delta^1 & & \Delta^3 & & \Delta^5 & \\
 & Y_0 & & \Delta^2_0 & & \Delta^4_0 & & \Delta^6_0 \\
\text{Interval} \Bigg(& & \Delta^1_0 & & \Delta^3_0 & & \Delta^5_0 & \\
 & Y_1 & & \Delta^2 & & \Delta^4 & & \\
 & & \Delta^1 & & \Delta^3 & & & \\
 & Y_2 & & \Delta^2 & & & & \\
 & & \Delta^1 & & & & & \\
 & Y_3 & & & & & &
\end{array}
$$

In Newton's method the top row of Δ is used, and for the top interval. Bessel, however, instead of the even differences takes the mean of the difference indicated and the one below it—that is to say, he adds in half of the next following value of odd differences. What this comes to we shall presently see; but, meanwhile, it is evident that the two methods are identical in result, so we need only take Lagrange's method. Lagrange deduced the following functions as expressing a result of finite differences (to the first difference add):—

$$
\begin{aligned}
&- x(1-x)\frac{\Delta^2}{1\cdot 2} \\
&- x(1-x)(1+x)\frac{\Delta^3}{1\cdot 2\cdot 3} \\
&+ x(1-x)(1+x)(2-x)\frac{\Delta^4}{4!} \\
&+ x(1-x)(1+x)(2-x)(2+x)\frac{\Delta^5}{5!} \\
&- x(1-x)(1+x)(2-x)(2+x)(3-x)\frac{\Delta^6}{6!}
\end{aligned}
$$

and so on.

Converting these functions into standard form, we get the result given in the following table (to the first difference add) :—

	P.	C.	IV.	V.	VI.
$\Delta^2 \times ($	$-\frac{1}{2}$				
$\Delta^3 \times ($	$-\frac{1}{4}$	$+\frac{1}{3}\frac{1}{4}$			
$\Delta^4 \times ($	$+\frac{3}{32}$	0	$-\frac{1}{9}\frac{3}{32}$		
$\Delta^5 \times ($	$+\frac{3}{64}$	$-\frac{7}{36}\frac{3}{64}$	$-\frac{1}{9}\frac{3}{64}$	$+\frac{1}{180}\frac{3}{64}$	
$\Delta^6 \times ($	$-\frac{5}{256}$	0	$+\frac{3}{20}\frac{5}{256}$	0	$-\frac{1}{900}\frac{5}{256}$

(The fractions are given as products to facilitate computation.)

Thus a value of the Lagrange Δ_0^4, for instance, equal to n, gives rise in the interpolation formula to the terms—

$$n\left(\tfrac{3}{32}\,(\mathrm{P}) - \tfrac{1}{96}\,(\mathrm{IV.})\right).$$

From this we see that, although it may be necessary to take the differences out to a high order, it does not follow that the formula necessary will be of high degree.

From this table we can at once see the improvement that Bessel made in Lagrange's formula, for it is evident that, taking half of the odd differences out in the term depending on the preceding even difference results in the elimination of the fractions which occupy the spaces in lines Δ^3, Δ^5, &c., column P, lines Δ^5, Δ^7, &c., in column IV., and so on. Thus Bessel's third difference function is the standard cubic, and the fifth a sum of cubic and quintic, which is an obvious improvement upon Lagrange's method.

It is not a complete improvement, for it does not alter to any appreciable extent Lagrange's even difference terms; and even with respect to the odd differences it includes a cubic term in the fifth difference function, instead of making it a pure standard quintic.*

If we compute by means of the table given above, it is clear that we are able to effect completely what the Bessel method effected partially, in giving the terms of the formula nearly the best possible form—that of the standard functions.

A concrete example of a problem treated by Lagrange's and Bessel's methods and by that of the standard functions will serve to show the advantages of the latter method.

Loomis's "Practical Astronomy," 1894, p. 207, gives a convenient example, that of getting the moon's R.A. from a twelve-hour table, for eight hours (*i.e.*, $x = \frac{2}{3}$). Two places of decimals are obviously enough, but we use three for the purposes of illustration.

---

* We here assume that the standard functions are the best practicable formulæ for convergence, concerning which *vide* the paper quoted.

Omitting the constant and the first-difference terms, which are the same in all methods, the data are :—

	Δ^2	Δ^3	Δ^4	Δ^5
	$+ 25{\cdot}68\ s.$		$- 2{\cdot}19\ s.$	
		$- 4{\cdot}08\ s.$		$- 0{\cdot}06\ s.$
	$+ 21{\cdot}60\ s.$		$- 2{\cdot}25\ s.$	
Mean	$+ 23{\cdot}64$		$- 2{\cdot}22$	

Lagrange's method gives :—

Δ^2	... ...	$- 2{\cdot}853{,}3\ s.$
Δ^3	... ...	$+ 0{\cdot}251{,}8$
Δ^4	... ...	$- 0{\cdot}045{,}7$
Δ^5	... ...	$- 0{\cdot}000{,}7$
		$- 2{\cdot}647{,}2\ s.$

The computation by Bessel's method gives :—

Δ^2 ...	$- \frac{1}{9}\,(23{\cdot}64)$	$=$	$- 2{\cdot}626{,}7\ s.$
Δ^3 ...	$(- 0{\cdot}00617)\ (- 4{\cdot}08)$	$=$	$+ 0{\cdot}025{,}2$
Δ^4 ...	$(+ 0{\cdot}02057)\ (- 2{\cdot}22)$	$=$	$- 0{\cdot}045{,}7$
Δ^5 ...	$(+ 0{\cdot}00069)\ (- 0{\cdot}06)$	$=$	$0{\cdot}000{,}0$
	Sum	...	$- 2{\cdot}647{,}2\ s.$

The values of Bessel's coefficients can be got from tables.

Now, for the standard method, filling in the tables, we get :—

	P.	C.	IV.	V.
$(+ 25{\cdot}68)\Delta^2$ gives	$- 12{\cdot}84$			
$(- 4{\cdot}08)\Delta^3$ "	$+ 1{\cdot}02$	$- 0{\cdot}34$		
$(- 2{\cdot}19)\Delta^4$ "	$- 0{\cdot}20{,}5$	$0{\cdot}0$	$+ 0{\cdot}02$	
$(- 0{\cdot}06)\Delta^5$ "	$- 0{\cdot}00{,}3$	$+ 0{\cdot}00$	$+ 0{\cdot}00$	$- 0{\cdot}00$
Sum	$- 12{\cdot}028$ (P)	$- 0{\cdot}34$ (C)	$+ 0{\cdot}02$ (IV.)	

Taking the values of P, C, and IV. from tables, as in the case of Bessel coefficients, or computing thus—

for $x = \frac{2}{3}$; $\mathrm{P} = \frac{2}{3} - (\frac{2}{3})^2 = + \frac{2}{9}$; $\mathrm{C} = + \frac{2}{9}\,(1 - \frac{4}{3}) = - \frac{2}{27}$; $(\mathrm{IV.}) = - \frac{2}{27}\,(1 - \frac{4}{3}) = + \frac{2}{8}$

we compute the terms :—

$$(+ \tfrac{2}{9})\ (- 12{\cdot}028) = - 2{\cdot}672{,}9\ s.$$
$$(- \tfrac{2}{27})\ (- 0{\cdot}34) = + 0{\cdot}025{,}2$$
$$(+ \tfrac{2}{81})\ (+ 0{\cdot}02) = + 0{\cdot}000{,}5$$

Sum ... $- 2{\cdot}647{,}2\ s.$

It is to be noticed that all the terms except the parabola have maximum ordinates of about 0·1, so that two places of decimals in their factors is ample. The quartic function, the term of which has here practically disappeared, has a maximum of 0·0625, so that the quantities it represents are never larger than 0·0013 in this interpolation, a quantity which is negligible with respect to the second place of decimals. This is against 0·052,0 in Bessel's method.

Comparing this with the Bessel's computation, we see that the fifth-degree term vanished in our table, while in the Bessel's its value was estimated, when it vanished; the fourth-degree term becomes negligible in our computation, while in Bessel's it is conspicuously large. The third-degree numbers are the same, 0·025,2. The Bessel's computation illustrates very clearly what was said about Bessel's method effecting an improvement only in the odd power terms.

It is hardly necessary to remark to those who may examine this method of using differences that there is no improvement on Newton's or Lagrange's methods for second differences, nor on Bessel's for third; but for fourth, and especially for higher differences still, the extra trouble of forming the table seems worth while, and certainly is worth while if a number of values have to be interpolated. The method of standard terms also possesses an obvious advantage where the problem is to find at what value of x, Y has a given value, since when fourth differences have to be used the approximation in three terms $[Y = A + Bx + C(x - x^2)]$ is more nearly accurate than the corresponding approximation of any of the other methods.

Note.

The standard functions referred to in this paper are :—

Parabola ...	(P)	=	$x\,(1-x)$
Cubic ...	(C)	=	$P\,(1-2x)$
Quartic ...	(IV.)	=	$C\,(1-2x)$
Quintic ...	(V.)	=	$C\,(1-4x)(3-4x)$
Hexic ...	(VI.)	=	$V.\,(1-2x)$
Heptic ...	(VII.)	=	$P\,(V.)$
Octic ...	(VIII.)	=	$P\,(VI.)$

and the list may be provisionally extended by P-multiplication. This list shows how the values of the functions for any value of x can be easily computed, or they may be taken from a table of values similar to those of the binomial coefficients (Newton's method) or of Bessel's coefficients. Such tables, it is confidently believed, will soon be included in many mathematical tables.

POSTSCRIPT.

A more extended table of the standard terms, which are equivalent to the Lagrange interpolation, has now been computed, and is given herewith. The form differs slightly from that of the shorter table in the paper, the common factors in each line being separated. These common factors are connected by the ratio $\frac{n-1}{2n}$ when n, the order of the factor sought, is even, $\frac{n}{2n}$ or $\frac{1}{2}$ when n is odd. Thus the table can be extended. Hence the common ratio is about $\frac{1}{2}$. The coefficients of the standard functions are also best extended by a similar process, but it is too complicated, and, moreover, obvious, to be here given. It will be necessary to construct a similar table for the Newton differences if it is required to treat functions of which the values cannot be given on each side of any interval.

It is to be noticed that the results of these operations are simply identical with the results of the orthodox methods, and where the latter fail for want of convergence these operations fail also. The advantage which the reductions possess is merely the shortening of the formulæ.

The practical use of this reduction lies, I think, in the power it gives in stating the values of functions in tabular form, where space forbids the use of more than a 2- or 3-figure argument. An example will now be given of the power of the standard method in this respect. First, we may notice the fact, which is evident from the table, that the Lagrange terms are, all of them, nearly pure standard parabolæ. That is to say, their maxima are nearly the same as the value when $x = \frac{1}{2}$. Consequently, the value or number represented by any of the Lagrange differences may amount to $\frac{1}{4}$ times the common factor for that difference.

The example taken is that of the log. gamma function, which was tabulated by Legendre for the unit interval 1 . . 2 in a 3-figure argument, 12-figure table, the interpolation being indicated by third differences, which were tabulated thus (twelve decimals understood) :—

	x	Log. Gamma.	Δ^1 (−)	Δ^2 (+)	Δ^3 (−)	Δ^4 (+)
(1)	·119	. . . .				
	·120	974 783 415 092	171 440 853	605 919	768	2
	·121	. . . .				

The last difference does not seem to have been given, and it is not necessary for Lagrange's method, and twelve places, but would have been needed for thirteen places, since it reaches the value 6 or $\frac{3}{32} \cdot \frac{6}{4} = 0{\cdot}14$ units in the twelfth place.

De Morgan (Diff. Calc., p. 587) gives an abridgment of this table in a 2-figure argument, to use which it is necessary to reconstruct one decad of the original table before an interpolation can be made, which obviously is a tedious process.

On differencing out the first portion of the 2-figure table, which appears to be the least convergent portion, I find that Δ^5 has a maximum of 1050 units, and Δ^6 of 50 units.

Hence, on the Lagrange system, Δ^5 represents $\frac{3}{64} \times \frac{1050}{4}$, or 12 units, and Δ^6 $\frac{5}{256} \times \frac{50}{4}$, or 0·24 units.

Now, reducing to the standard system, Δ^6 will be represented by $\frac{5}{256} \times \frac{50}{900}$, or 0·001 (VI.), with a maximum value of about 0·000,1 units, and Δ^5 by $\frac{3}{64} \cdot \frac{1050}{180}$, or 0·3 (V.), with a maximum of 0·03 units, or 0·3 units in the thirteenth place.

Summing up, we need for a 12-figure table—3-figure argument, three differences; 2-figure argument, five differences, or four standard terms: and for a 13-figure table—3-figure argument, four differences; 2-figure argument, six differences, or four standard terms.

The following is a specimen line of a 2-figure table in terms of Lagrange differences and in standard terms:—

Lagrange Differences.

x	Log. Gamma.	Δ^1 (−)	Δ^2 (+)	Δ^3 (−)	Δ^4 (+)	Δ^5 (−)	Δ^6 (+)
(1) · 11	....						
· 12	974783415092	1687233927	60670390	761542	18304	605	34
· 13	....						

Standard Terms.

x	Log. Gamma.	Δ^1 (−)	P (−)	C (−)	IV. (−)
(1) · 11	....				
· 12	974783415092	1687233927	30143123	63456	190
· 13	....				

These are the actual numbers. If any one wishes to check them it should be noticed that the differences in the original table are Newton's or leading differences, so that the interpolation must be made with the binomial coefficients, and not with Lagrange's or Bessel's functions.

Finally, it may be noticed that if it is preferred not to use the standard functions their terms might be translated back into Lagrange or Bessel differences, so that existing tables may be used for interpolating without losing the advantage of the reduction.

EXT[illegible] TABLE FOR REDUCING LAG[illegible] [illegible]FFERENCES TO STANDARD [illegible]NCTIONS

Order of Differences.	Common Factor.	P	C	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.
Δ^2	$\frac{1}{2}$	-1											
Δ^3	$\frac{1}{4}$	-1	$+\frac{1}{3}$										
Δ^4	$\frac{3}{32}$	$+1$	0	$-\frac{1}{9}$									
Δ^5	$\frac{3}{64}$	$+1$	$-\frac{7}{36}$	$-\frac{1}{9}$	$+\frac{1}{180}$								
Δ^6	$\frac{5}{256}$	-1	0	$+\frac{3}{20}$	0	$-\frac{1}{900}$							
Δ^7	$\frac{5}{512}$	-1	$+\frac{11}{80}$	$+\frac{3}{20}$	$-\frac{131}{25200}$	$-\frac{1}{900}$	$-\frac{4}{6300}$						
Δ^8	$\frac{35}{8192}$	$+1$	0	$-\frac{19}{112}$	0	$\frac{+109}{58800}$	0	$\frac{+1}{11025}$					
Δ^9	$\frac{35}{16384}$	$+1$	$-\frac{143}{1344}$	$-\frac{19}{112}$	$\frac{+9539}{2116800}$	$\frac{+109}{58800}$	$\frac{+323}{396900}$	$\frac{+1}{11025}$	$\frac{+16}{396900}$				
Δ^{10}	$\frac{63}{65536}$	-1	0	$\frac{+2195}{12096}$	0	$\frac{-8971}{3810240}$	0	$\frac{-647}{3572100}$	0	$\frac{-16}{3572100}$			
Δ^{11}	$\frac{63}{131072}$	-1	$\frac{+4199}{48384}$	$\frac{+2195}{12096}$	$\frac{-655541}{167650560}$	$\frac{-8971}{3810240}$	$\frac{-131977}{157172400}$	$\frac{-647}{3572100}$	$\frac{-2572}{39293100}$	$\frac{-16}{3572100}$	$\frac{-64}{39293100}$		
Δ^{12}	$\frac{231}{1048576}$	$+1$	0	$\frac{-33593}{177408}$	0	$\frac{+333167}{122943744}$	0	$\frac{+5935}{23051952}$	0	$\frac{+92}{8820900}$	0	$\frac{+64}{432224100}$	
Δ^{13}	$\frac{231}{2097152}$	$+1$	$\frac{-7429}{101376}$	$\frac{-33593}{177408}$	$\frac{+21947281}{6393074688}$	$\frac{+333167}{122943744}$	$\frac{+975761}{1198701504}$	$\frac{+5935}{23051952}$	$\frac{+440617}{5618913300}$	$\frac{+92}{8820900}$	$\frac{+17968}{5618913300}$	$\frac{+64}{432224100}$	$\frac{+256}{5618913300}$

NOTE.—If it is preferred to arrange the differences in the Bessel fashion, the Lagrange table will apply, provided that all the numbers which are on the same diagonals as the zeros are also made zero. In other words, all the numbers which lie below the same number must be made zero.

Art. LV.—*On New Zealand Mean Time, and on the Longitude of the Colonial Observatory, Wellington; with a Note on the Universal Time Question.*

By Thomas King, Transit Observer, Colonial Observatory.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

(A.) New Zealand Mean Time.

The public attention which has been given of late to the international movement in favour of the adoption of what is known as the universal or standard time system—an extremely convenient scheme for co-ordinating the various clock-times of the world—seems to make it worth while telling how New Zealand settled the question of time-simplification for herself before any proposals for a change had begun to be agitated elsewhere. It is not as commonly understood as it should be that, in arranging a time-reckoning for her own use, this colony as early as 1868 fixed upon practically the very principle which was afterwards embodied in the reform in question, and that she was thus, apparently, the first country in the world to take up the improved system.* It is one of the purposes of the present paper to explain how this came to pass.

The question has once before been before this Society, for at a meeting held on the 12th October, 1868, it was dealt with by Dr. (now Sir James) Hector in a paper which will be referred to presently.† But that was a good long while ago, and in the interval which has elapsed the inevitable oblivion has overtaken the work of those early days. Yet the action of our colony in this matter is not without a certain modest importance for us; and, as the recent progress of the reform in other countries has lent the subject an interest wider than that which it could originally claim, I venture to hope that in discussing it now I shall not be considered open to the charge of needlessly reviving an old story.

In the first stages of the colony's existence, and for a considerable period afterwards, no special need was felt for a general system of time-observance. Each district seems to to have kept the approximate local mean solar time of its

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* See "The Observatory" for July, 1901, vol. xxiv., p. 291, paragraph on "The Time of New Zealand."

† "On New Zealand Mean Time" (Trans. N.Z. Inst., vol. i., p. 48; second edition, p. 451).

principal town (or of some other place which was judged more suitable) without reference to the times adhered to in other districts, and we thus had four distinct times. This worked well enough for many years. When communication between the different parts of the country was slow and our over-sea trade was carried on chiefly by means of sailing-vessels, the inconvenience arising from diversity of times was scarcely appreciable. But with the acceleration of the colony's coastal carrying services, with the introduction of steam navigation between Australian and New Zealand ports, and, above all, with the rise of our railway and telegraph systems, the case was altered. By the middle "sixties" it was realised that some more uniform plan was essential. The question was discussed at intervals without action immediately resulting; but at last, in 1868, Dr. Hector was asked by the Government to submit proposals for a standard time suitable for use throughout the whole colony. The subject of time reform had before this engaged his attention. In 1860—at the close of his exploration-work in the Rocky Mountains and on the Canadian-United States frontier—he had pointed out in a report to the Canadian Government the modification of the existing reckoning which would be found necessary on the long route of the Canadian Pacific Railway. Canada and the United States were ultimately forced by circumstances to adopt this modification.

Under the new system clock-times are made to change by even intervals of an hour on the journey east or west across the American Continent, the minutes and seconds of all clocks, in whatever longitude they may be situated, remaining the same. The United States and Canada were the earliest countries of importance to rationalise their times in this way, and it has been largely due to their efforts that a similar reform has been wrought in other parts of the world. Canada in particular was honourably active in pressing the question upon the attention of Europe.

I do not know if Sir James Hector is disposed to claim that his prediction may have been the germ from which the movement in North America originated; but whether the hint was fruitful or not it would appear as if in point of fact he was first in the field. The earliest advocacy of such a scheme which is reported in the ordinary accounts of the reform was contained in a pamphlet published ten years afterwards by Professor C. Dowd, of Saratoga Springs, who advanced a proposal for hourly meridians, based, however, on Washington time. But the point with which we are now concerned is that in making his recommendation to the New Zealand Government in 1868 Dr. Hector had this sensible principle of hourly meridians in his mind.

For the clear understanding of what follows, a reference to the map of New Zealand is desirable. It will be seen that the colony covers a breadth of about 12° of longitude—from about 178° 36′ east at the East Cape to about 166° 26′ east at the West Cape in the Sounds district, Fiord County. Converting these longitudes from arc into time, we get local times of about 11 h. 54 m. fast on Greenwich at the East Cape and about 11 h. 6 m. fast on Greenwich at the West Cape, a range of a little over three-quarters of an hour. The average meridian is therefore 172° 31′, or nearly 11 h. 30 m. in time.

Again, the meridian which has an equal area of land on either side of it is 172° 49′, the time-equivalent of which is 11 h. 31 m.

Finally, the average meridian of the principal ports is 173° 14′, or in time 11 h. 33 m.

If, then (it was pointed out by Dr. Hector), the mean solar time of the meridian 172° 30′ east, equivalent to 11 h. 30 m. fast on Greenwich, were selected, it would appear to afford the best standard for the colony. This time would be slow on the local mean solar time of Napier only some 17½ m., and fast on the local mean solar time of the Bluff only about 16½ m.; while in the cases of the other ports it would be even nearer to the respective local times. To obtain the local times of the several ports we should have to add or subtract from the time of the suggested meridian the following differences (I give the corrections roughly to the nearest half-minute of time):—

For Auckland	...	Add	9 minutes.
„ Napier ...	...	„	17½ „
„ New Plymouth	...	„	6 „
„ Wellington	...	„	9 „
„ Nelson ...	...	„	3 „
„ Picton ...	...	„	7 „
„ Lyttelton	...	„	1 „
„ Westport	...	Subtract	3 minutes.
„ Port Chalmers	...	„	7½ „
„ Bluff ...	...	„	16½ „

"The object being to establish for the whole colony one time the adoption of which would cause the least inconvenience," Dr. Hector recommended to the Government that the 11½ h. meridian should be adopted. In his paper above mentioned he claimed for this plan, *inter alia*, the following advantages:—

First, it is a close approximation to the average longitude for the colony.

Second, longitude 17° 30′ east is 11 h. 30 m. fast on Greenwich; and, being an even number, will be most suitable for the purpose of enabling mariners to compare their chronometer-times with true Greenwich mean time.

Once more consulting the map, we shall find that neither of the two alternative meridians possessing this special advantage for navigators and others is so convenient for the general purposes of the colony. The 11 h. meridian (165° east) falls in the ocean about a third of the distance between Wellington and Melbourne: the 12 h. meridian (180° east) lies at a corresponding distance from the East Coast, well out towards the Chatham Islands. Dr. Hector therefore had no hesitation in putting forward his proposal in favour of the 11½ h. meridian. The Government approved the suggestion, and laid it before the House of Representatives; and on the 31st October, 1868, a *Gazette* notice was published announcing that the House had passed a resolution to the effect that the time 11½ hours in advance of Greenwich mean time had been adopted as the mean time for the colony, and that from the 2nd November, 1868, the public offices of the General Government would be opened and closed in accordance therewith.*

The "Hector" time-reckoning for New Zealand has thus been in force ever since 1868. It is very convenient for all the civil purposes of the colony; it is instantly intelligible to navigators; and its adoption has enabled New Zealand to take her place in the official list of countries obeying the standard time agreement, although that agreement had not been heard of when our Legislature took this action. It may be said that the idea is a very obvious one, and that any country might have arranged to follow it in deciding upon the basis of its time system. This is perfectly true: it is obvious enough—after it has been adopted; but the fact remains that no other country did take it up for something like fifteen years after it had been adopted for New Zealand.

All things considered, the standard bids fair to be the one permanently used by the colony. Admirably, however, as it would appear to answer our needs, suggestions have not been wanting that it should be modified. The contention is that a system based on an exact hour east of Greenwich would be a more complete realisation of the standard time ideal than one having an odd half-hour in its count, and that therefore we ought to make our time either 11 h. or 12 h. fast on Greenwich. Now, it must at once be admitted that, other things being equal, the integral number of hours is preferable to the number which includes the half-hour. The question is whether, for the sake of symmetrical compliance with the letter of the standard time arrangement, it is desirable to upset our system. It appears to me that, except upon very

* *New Zealand Gazette*, 31st October, 1868, p. 505.

clear showing of necessity, it would be unwise for the colony to abandon its standard. What we have to decide is how far the practical convenience for us of our present reckoning should stand against a demand for the somewhat neater appearance which would be secured if we could write our time in almanacs and other publications as either 11 h. or 12 h. fast on the initial meridian. The following points may be submitted for consideration:—

(1.) In a country of moderate dimensions like New Zealand it is desirable that only one clock-time should be observed.

(2.) It is convenient that such clock-time should deviate as little as may be from the actual mean time of any part of the country.

(3.) It is convenient that over the whole country similar clock-hours of business should be observed.

(4.) It is desirable that the time kept for ordinary business and social purposes should be the same as that used for the railway and telegraph services. Yet—

(5.) It is important that our reckoning should, notwithstanding the above, be in harmony with the spirit of the international system which has found such wide acceptance.

All these conditions are fulfilled by our existing system.

As regards the four first, it should be noted that New Zealand has considerable range in longitude. The narrowness of the islands is apt to mislead us on this point. But from the East Cape to the south-west of Otago the trend of the country is markedly westwards. The difference between the longitude of the East Cape and the longitude of the West Cape is greater than the difference between the longitude of the extreme east coast of England and that of the extreme west coast of Ireland. Yet, though Greenwich time (which is the time of a meridian in the east of England) is convenient enough for England and Scotland, Ireland, for her railways and for all purposes except those of the telegraph service, finds it advisable to keep Dublin time, which is twenty-five minutes slow on Greenwich. To put it in another way: The difference between the longitudes of our east and west coasts is about equal to the difference between the longitude of London and the longitude of a meridian running through central Germany. Yet Germany keeps a time one hour fast on the time kept in London.

It follows that if we adopted the even-hour plan we might be obliged to have two standard meridians—the 11 h. standard for the western half of the colony and the 12 h. standard for the eastern half. Or, if only one of these meridians were taken for our official time, we might find ourselves using some local time in that part of the colony which lay too far from

the selected meridian to make the time of the latter suitable for local purposes without some alteration in the nominal hours of business. Or, lastly, if all parts of the colony adhered to one official reckoning—11 h. or 12 h. fast on Greenwich—we might have different clock-hours of business observed in different districts; which, in a relatively small country having close intercommunication, is a nuisance to be avoided if practicable.

New Zealand is not alone in its modification of the integral-number ideal. Other countries have been confronted with the same difficulty, and have overcome it in the same way. Cape Colony, Orange River Colony and the Transvaal keep a time 1½ h. fast on Greenwich. The 1 h. meridian falls too far to the west—out in the Atlantic; the 2 h. meridian is too far to the east: therefore these three countries have compromised in a practical manner by taking the 1½ h. meridian for their standard. (South Australia also keeps a time based on the half-hour principle; but for a reason which I will presently explain I do not cite her as an example to be followed.)

Now, notwithstanding this departure from literal conformity with the hour-meridian principle, the countries which I have mentioned, together with New Zealand, are recognised in all the usual lists (*e.g.*, in that given each year in the "Nautical Almanac") as coming under the standard time agreement. There has been no very earnest attempt amongst leading scientific authorities to induce the countries making use of this modification to abandon it; and it appears to be generally admitted that we are acting reasonably in adapting the system to this extent to the peculiarities of our respective geographical positions. We may claim, then, that the fifth of the conditions advanced above is, like the other four, sufficiently respected by our reckoning. Of course in a certain sense it may be said that it does not much matter what clock-time a country may keep, since ultimately our social arrangements are ruled by the sun. It is conceivable that some day one uniform clock-time will be in force all over the world, so that, while the sun may rise in one place at 6 o'clock, in another it will not rise until, say, 12 o'clock. All I mean to contend for now is that, whilst we keep a clock-time approximating to local mean solar time, the closer the approximation is, consistent with other considerations which must be studied, the better.

But it is sometimes suggested that a reform of the clock should be made for another reason. It is argued that if New Zealand adopted a time 12 h. fast on Greenwich a wholesome change would be effected in our habits. We should all get up half an hour earlier than we do at present,

and retire to rest half an hour sooner. There seems to be here some confusion of reasoning. If we wish as a community to make such an alteration in our actual times of working and resting we can easily do so; but there is no need whatever for tampering with our clocks in the process, so as to make them show that no change in our habits has taken place. The proposal is surely a trifle otiose. If a man wants to go to bed at 10 o'clock instead of at 11 he generally does so without finding it essential to his peace of mind to put on the clock an hour.

Some of those, however, who advocate this modification of our standard for hygienic reasons take rather different ground. They admit that it is absurd to suppose that before we can alter our ways we must gravely perform the ceremony of moving forward the hands of the clock; but they urge that, as people are accustomed to fulfil all their engagements of business and recreation at certain times by the clock, if we can only get them to consent to alter the clock they will continue to keep those engagements at the same nominal clock-hours, thus making earlier by the amount of the change their actual times of working and resting. The argument does not seem to me to be convincing. It is far from evident that our community is quite so subrational in its thinking as the theory assumes. The real point is missed. The question is not whether such a change in our habits is desirable, but whether it is desired by those concerned. If it is desired it will be made readily enough; if it is not desired, depend upon it that those who recommend it will have to wait until they have converted their fellows to their way of looking at the matter. Men presumably now consent to obey the indications of the clock because those indications bear a certain convenient relation to the time *realities* by which they are guided in arranging their lives. If those clock indications are altered, and people do not otherwise seek a change, they will cease to obey them to the extent of the alteration; in other words, they will amend their nominal hours of business so as to make them continue to be the same in actual time as they were before, unless, of course, the alteration in the clock is so small as to pass unnoticed—and that cannot be contended in the present case. It is the sun, and not the clock (a mere measuring-machine), which really determines our arrangements. As Sir Charles Todd, Government Astronomer for South Australia, put it a few years ago: "The name we give to an hour is not of very much consequence. What we do in practical life is to adapt our movements to the duration of daylight."

I have referred above to the case of South Australia. The people of South Australia (unlike, apparently, the people of

New Zealand at present) did desire to make such a change in their habits as our hygienic reformers aim at. They believed that they would be at a disadvantage in business matters as compared with Victoria and New South Wales unless they began business earlier, and they also considered that it would be to their benefit if they had more daylight time for recreation after business hours. Very properly, therefore, they resolved to begin and end their day's work half an hour earlier. But in doing so they must needs carry what one of their own newspapers called their "slavery to habit" to such a pitch as to falsify the clock to correspond with the change. They had originally (in February, 1895) adopted the time of the meridian 135°—viz., 9 h. fast on Greenwich—which correctly enough represented the time of the bulk of their territory; but when they decided upon making the change in question they abandoned this in favour of the time 9½ h. fast on Greenwich (going beyond their eastern border for a meridian), and this time since April, 1899, has been the standard for their State. As a South Australian paper said, "If commercial advantages are to be gained by manipulating the reckoning of time, the question occurs whether our rivals may not seek to keep what they have, and start the colonies on a war of clocks. That would be, indeed, a *reductio ad absurdum.*" If one may criticize a neighbouring State, I would express the opinion that just as there is no need for New Zealand to give up the half-hour reckoning, so there was no justification for South Australia adopting such a reckoning. Circumstances alter cases. The half-hour time is correct for us, but in South Australia it meant a departure from correctness, and one for which there was no call, as there might conceivably be if one time for the whole of Australia were proposed.

The believers in the desirableness of a change in the time of New Zealand, therefore, are thrown back upon the original argument—namely, that a 12 h. time would represent a more complete fulfilment of the standard time idea; and with this argument I have, I hope, dealt fairly. Of course it is conceivable that at some future time the conditions of the case may be altered; and if there should then be a general and strong feeling amongst European and American reformers that we should take up an integral-hour reckoning (say, the 12 h. one), probably New Zealand would be enlightened enough to comply, and to adapt her arrangements to the change. Such adaptation would most probably take the shape of a corresponding alteration of her nominal times of business and pleasure, and where then would be the gain from the point of view of the health reformers?

What I have tried to prove is that the balance of advantage at present is with our existing 11½ h. reckoning, and that

we are not called upon to abandon this standard unless it can be unmistakably demonstrated to us that our refusal to change will appreciably affect the prospects of the time-reform movement. No attempt to show this has, so far as I am aware, been made, and reformers generally seem to acquiesce in the compromise which we, in common with the three South African colonies referred to, have been led by circumstances to make.

(B.) The Longitude of the Colonial Observatory, Wellington.

The subject of New Zealand standard time naturally leads to the cognate subject of the longitude of the standard meridian of the time-service, or, in other words, of the longitude of the Wellington Observatory. This already has a voluminous literature of its own; but the details are scattered over so many parliamentary reports and past volumes of the "Transactions of the New Zealand Institute" that it will be useful for purposes of future reference if the essential facts are brought together in one paper.

Before dealing with the question of the longitude, perhaps I may be allowed to give a few particulars about the Observatory and its origin. The present Wellington Observatory was established in 1869 as a result of the decision of Parliament to institute one uniform time for the colony. It is a time-service observatory pure and simple, and therefore structurally it is of but modest proportions, consisting merely of a transit-room and a clock-room. Its equipment, however, is of the best, and entirely sufficient for the purpose. The transit instrument, of 2¾ in. aperture and 32 in. focal length, is an excellent one by Troughton and Simms. It is substantially mounted in the usual way on a pyramidal brick pier resting on a solid foundation of rock, and is duly isolated from contact with the building and carefully protected from surface tremor. The meridian-mark is a 3 in. iron pillar, deeply set in concrete, standing about 6 ft. high on the sky-line of the Tinakori Range, a sufficient distance to the northward, near Wadestown. There are four fine clocks —one of them a sidereal clock, and the other three mean solar time clocks. They are mounted on brick and cement bases, and are fastened to substantial timber frames stayed by steel rods to prevent disturbance of the adjustments. They are good time-keepers; and, as there are three mean time clocks, by a combination of the rates practically true time can always be given, even when bad weather stands in the way of observations. The sidereal clock, by Dent, is provided with a magnetic chronograph by the same

maker. One of the mean time clocks is also by Dent, and is an instrument of the same class as the sidereal clock, with zinc and steel compensation. A second mean time clock, by Moore, of Clerkenwell, has a mercurial compensation; and the third mean time clock, by Moore, is the one which drops the time-ball and sends signals to various parts of the colony. This clock is fitted with an electro-magnetic apparatus which enables the clock to signal time automatically every hour to certain places in town (the Museum, the Telegraph Office, and the shops of the leading watchmakers) and to drop the time-ball on Waterloo Quay at noon each day. The same clock is frequently placed in direct connection with the telegraph offices at Lyttelton and Port Chalmers, and thus signals true time, without human intervention, for the use of navigators at those ports. If the time-balls at Lyttelton and Port Chalmers—and, indeed, the one at Auckland also—were equipped with the necessary electro-magnetic dropping gear, they could be operated by the clock direct from the Observatory, just as our own time-ball now is; a distinctly better plan than the present one, under which uniformity of time at the several ports is not easily secured. Still, any navigator at Auckland, Lyttelton, or Dunedin (or at any other port) can, through the co-operation of the Telegraph Department, obtain time-signals direct from Wellington Observatory in case he feels dissatisfied with the indications given him by the local time-balls; and this opportunity is frequently taken advantage of by the commanders of merchant ships and the navigating officers of men-of-war. Sometimes special signals are sent for important purposes. Thus, when H.M.S. "Penguin" a year ago wished to determine the longitudes of Tauranga and Gisborne, a series of time-signals was exchanged between the Observatory and the ship at each of those two ports; and again, when the antarctic exploring ships "Discovery" and "Morning" were in the colony and about to sail south, a succession of exact signals was sent night after night by special wire from the Observatory to the officers' cabin of either vessel as she lay at the wharf at Lyttelton.

From the magnetic signal which is sent by the clock at 9 a.m. each day to the operating-room of the Wellington Telegraph Office time is repeated by an officer of the Department (using an ordinary Morse instrument) to all the telegraph offices in the colony. This hand-sent signal is not intended for chronometer-rating purposes, and is therefore despatched merely with sufficient accuracy for ordinary office use and for the purpose of enabling all the telegraph and railway clocks in the colony to be set daily to a common time. Practically

every telegraph office and railway-station throughout the country is thus regulated frequently and uniformly to the central time.

The reasons for the selection of Wellington as the position for the Observatory were strong ones. They were set forth by Dr. Hector and the late Archdeacon Stock in 1868, and were emphasized by Chief Surveyors J. T. Thomson and Henry Jackson some three years later. On the 19th October, 1868, the Rev. Mr. Stock, who for about five years previously had been in charge of a small time-ball observatory built by the Provincial Government of Wellington on land now occupied by the General-Post Office, addressed a letter to the Hon. John Hall, Postmaster-General, pointing out that the site of the Observatory was no longer suitable, and urging that the General Government should erect an improved Observatory on a more satisfactory spot. In support of this suggestion he wrote: "I need hardly say that Wellington, being the centre of the telegraph system, is the best place for the Observatory, which would have to use the telegraph wires."*

In a memorandum to the Hon. W. Gisborne, written on the 18th of the following month, Dr. Hector endorsed the suggestion of Mr. Stock and the reasons advanced in its favour, and he proposed the site which was ultimately chosen, a knoll behind the cemetery in Bolton Street.†

Again, on the 21st September, 1871—the Observatory in the meantime having been built and been doing good work—Messrs. Thomson and Jackson, in a report to the Government‡ on the subject of the longitude of the new Observatory in its relation to the longitudes of certain other places in the colony, said, "There will . . . . be three points in New Zealand, extending nearly along the whole length, two of which will have been referred to an initial meridian at Wellington. Such being the case, and actuated by the same motives which first induced us to determine the absolute longitudes in our respective provinces, we beg to submit for the consideration of the Government that there shall be an initial meridian for the reference of all longitudes in New Zealand, at Wellington, which, as its capital, and from its central position, is the most eligible site that could be chosen; and that this initial meridian be that of the Government Observatory."

* Appendix to Journals of House of Representatives, D.-No. 39, 1870.

† *Ibid.*

‡ Appendix to Journals of House of Representatives, G.-No. 23, 1871.

Ministers gave favourable attention to the proposals submitted to them, the Hon. John Hall minuting Dr. Hector's memorandum with the remark: "As the General Assembly has directed New Zealand mean time to be kept throughout the colony, some provision for ascertaining that time with exactitude is indispensable. The arrangement here suggested seems as good as can be made" (28th November, 1868).*

The erection of the Observatory was accordingly authorised; the building was put in hand at once, and finished in June, 1868; and the instruments were placed in position by the following October. The adjusting of the transit instrument and other necessary arrangements delayed matters until the end of the year; but in January, 1870, the work of the time-service was begun under Dr. Hector as Director and the Rev. Mr. Stock as Observer; and it has been carried on continuously ever since. Archdeacon Stock was Observer until August, 1887, when failing health obliged him to retire.

Early attention was devoted to the longitude of the Observatory. There have been several determinations of this. The most reliable have been effected by means of the fixing of the meridian distance from Sydney Observatory, and the work of determining this difference has been accomplished with close accuracy. But Sydney Observatory, although its longitude, like that of Melbourne Observatory, is *now* supposed, as the result of direct telegraphic comparison with Greenwich, to be very exactly known, has been yet compelled on several past occasions to revise its assumed longitude. Wellington Observatory, dependent as it has been on Sydney as the prime meridian, has therefore had to make corresponding corrections in its assumed longitude. But these changes have not been serious. Fortunately, Melbourne, at a very much earlier date than Sydney, was able to obtain a longitude which has not called for appreciable revision; and as it was known about thirty years ago that the Melbourne determination was more reliable than the Sydney one (seeing that the Melbourne value had been arrived at by cable from Greenwich, whilst the Sydney value had been obtained from observation), and as, moreover, the difference between the longitudes of Sydney and Melbourne had been ascertained then by the use of the telegraph line, it was possible to arrive at a value for Wellington Observatory derived from the Sydney longitude corrected on the basis of the Melbourne longitude, and this corrected value has been shown by subsequent investigations to have been extremely near the mark.

* Appendix to Journals of House of Representatives, D.-No. 39, 1870.

It is interesting to note some of the alterations which have been made in the recorded longitude of Sydney Observatory during the past thirty years, and to compare them with the smaller corrections which have been necessary in the assumed longitude of Melbourne. From old volumes of the "Nautical Almanac"* and from other sources we find that since 1874 the following values have been used for these two observatories:—

Sydney.	Melbourne.
H. M. S.	H. M. S.
E. 10 4 53·37†	E. 9 39 54·8
10 4 53·90†	...
10 4 50·61	...
10 4 47·3	...
10 4 50·8	...
10 4 49·6	9 39 53·8
10 4 48·9	...
10 4 48·47	...
10 4 49·54‡	9 39 54·15‡

The first reliable determination of the difference of longitude between Sydney and Wellington was effected in the years 1852 and 1854 by H.M. ships "Acheron" and "Pandora," under Captain J. L. Stokes and Commanders G. H. Richards and B. Drury, by the transport of chronometers from Sydney to Wellington during the course of the complete survey made by those vessels of the New Zealand coast. The place selected in Wellington was a spot near Pipitea Point, on what is now the railway-line (it used to be marked on the old charts as "Observation Spot"). When the Observatory was afterwards built its difference of longitude from that position (viz., 2·88 s.§) was easily ascertained by triangulation. The result thus obtained was subsequently confirmed by telegraphic determinations. In 1876 Mr. H. C. Russell at Sydney Observatory and Archdeacon Stock at Wellington Observatory exchanged a series of cable time-signals which gave a mean result accordant with that of Captain Stokes to within about half a second of time, showing how admirably that officer had done his work;|| and again, in 1883, Mr. Russell at Sydney Observatory and

* See "Nautical Almanac" for 1883, 1889, 1894, 1896, 1897, 1898, and 1903.

† Absolute determination.

‡ Present value.

§ The transit pier of the Observatory is 5015·6 links west of Observation Spot at Pipitea, equal to 2·88 s. in time.

|| See Trans. N.Z. Inst., vol. ix., 1876, p. 217: "On the Longitude of Wellington Observatory," by Ven. Archdeacon Stock, B.A.

Mr. C. W. Adams, New Zealand Geodesical Surveyor, at the Survey Department's observatory which then stood on the site at Mount Cook afterwards taken for the prison buildings, by another series of careful telegraphic exchanges arrived at a result almost identical with that of Mr. Russell and Archdeacon Stock, allowance, of course, being made for the difference (1·21 s.*) between the longitudes of Mount Cook Observatory and Wellington Observatory, as derived from triangulation. (The respective personal equations of Mr. Russell and Mr. Adams were tested and taken into account in the final examination of their work.) These three determinations compare as follows:—

Difference of Longitude, Sydney and Wellington.

	Wellington Observatory East of Sydney Observatory.		
	H.	M.	S.
Stokes's chronometric determination ...	1	34	15·28
Russell and Stock's telegraphic determination	1	34	15·99
Russell and Adams's " "	1	34	15·77

There was another chronometric determination—viz., by Captain G. S. Nares, of H.M.S. "Challenger" (see his memorandum to Dr. Hector, printed in vol. vii. of the "Transactions of the New Zealand Institute," 1874, p. 502). This gave the meridian distance of Wellington Observatory as 1 h. 34 m. 17·23 s. E. of Sydney Observatory; but, as Captain Nares himself pointed out, his result was not so trustworthy as that of Captain Stokes, as an interval of twenty-one days elapsed between the "Challenger's" observations at Sydney and Wellington, whereas Captain Stokes is supposed to have run his distance directly from Sydney to Wellington, and thus to have secured his observations at the two ports within a less interval of time. Captain Nares's determination was therefore not accepted.

The following table shows the several longitudes for Wellington Observatory resulting from these determinations, with the changes rendered necessary from time to time by the corrections made in the longitude of Sydney:—

* Mount Cook Observatory was east of Wellington Observatory 2097·2 links = 1·21 s., as is shown in a copy of a departmental memorandum kindly furnished to me by Mr. Marchant, Surveyor-General.

Determination.	Longitude of Sydney Observatory being assumed as	Difference of Longitude, Wellington-Sydney Observatories.	Resulting Longitude for Wellington Observatory.	Remarks.
	East. H. M. S.	East. H. M. S.	East H. M. S.	
Stokes's chronometric	10 4 53·37 (absolute determination)	1 34 15·28	11 39 8·65	This was the value placed on the charts (*i.e.*, Pipitea Point = 11 h. 39 m. 11·53 s., deducting from which 2·88 s.—the difference between Pipitea Point and the Observatory—we get 11 h. 39 m. 8.65 s.).*
Ditto	10 4 53·90 (absolute determination)	1 34 15·28	11 39 9·18	As in Archdeacon Stock's paper "On the Longitude of Wellington Observatory," 1876, Trans. N.Z. Inst., vol. ix., p. 217.
Ditto	10 4 50·61 (depending on Melbourne)	1 34 15·28	11 39 5·89	As in Dr. Hector's letter of 9th September, 1874, to Colonial Secretary, covering memorandum from Captain G. S. Nares, of H.M.S. "Challenger" (Trans. N.Z. Inst., 1874, vol. vii., p. 502); also as in Major H. S. Palmer's Report on Longitudes, 1875–76, in Appendix to Journals of House of Representatives, H.-No. 6, 1876.
Ditto	10 4 49·54 (telegraphic determination now accepted)	1 34 15·28	11 39 4·82	
Russell and Stock's telegraphic (1876)	10 4 50·61 (depending on Melbourne)	1 34 15·99	11 39 6·60	See Archdeacon Stock's paper above mentioned.
Ditto	10 4 49·54 (accepted telegraphic)	1 34 15·99	11 39 5·53	
Russell and Adams's telegraphic (1883)	10 4 48·47	1 34 15·77	11 39 4·24	Sydney Observatory to Mount Cook Observatory, 1 h. 34 m. 16·98 s., less difference Mount Cook and Wellington Observatories 1·21 s. = 1 h. 34 m. 15·77 s.
Ditto	10 4 49·54 (accepted telegraphic)	1 34 15·77	11 39 5·31	

* See Report of Board of Longitude, Appendix to Journals of House of Representatives, D.-No. 27, 1870.

In addition to these chronometric and telegraphic determinations, there have been three "absolute" determinations —that is, determinations by means of observations of moon culminations, &c. Before the present Observatory was built, Captain Carkeek, with the view of ascertaining the longitude of the old time-ball tower, conducted for many years a series of observations in the shape of lunars, eclipses of Jupiter's satellites, lunar eclipses, and moon culminations.

Then, in 1869, 1870, and 1871, Chief Surveyors J. T. Thomson and Henry Jackson, at their respective private observatories at Rockyside (Caversham, Dunedin) and the Hutt, by observations of moon culminations determined the longitudes of those points. Having done so, they settled by means of the electric telegraph the difference between the longitudes of their two observatories, as a check upon their independent determinations. Mr. James McKerrow, afterwards Surveyor-General, assisted Mr. Thomson at Rockyside in this important branch of the work.

By triangulation from the old time-ball site to the Wellington Observatory, and from Mr. Henry Jackson's private observatory to Wellington Observatory, values were thus obtained for the longitude of Wellington Observatory.

Finally, in 1874–75, Major H. S. Palmer, R.E., chief of the English expedition to New Zealand for the observation of the 1874 transit of Venus, conducted a series of observations at Burnham (his observing-station in Canterbury) for the determination of the longitude of that place. Professor C. H. F. Peters, chief of the United States Transit of Venus party, about the same time made similar observations for longitude at his station at Queenstown, Lake Wakatipu. Then these two points, with Mr. Heale's temporary observatory at Auckland, the Colonial Observatory at Wellington, and Mr. Thomson's observatory at Caversham, were connected by telegraph, with the object of ascertaining their respective differences of longitude. Major Palmer himself came to Wellington and conducted the work necessary for fixing the longitude of the Wellington Observatory on this basis.

The results of these absolute determinations (or, to use Major Palmer's term, "approximate absolute determinations") were as follows:—

(1.) Captain Carkeek's approximate absolute,* 11 h. 39 m. 15·75 s. E.

(2.) Messrs. Thomson and Jackson's approximate absolute,* 11 h. 39 m. 15·31 s. E.

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* For an account of Captain Carkeek's and Messrs. Thomson and Jackson's determinations see Messrs. Thomson and Jackson's report to Government, Appendix to Journals of House of Representatives, G.-No. 23, 1871.

(3.) Major Palmer's approximate absolute,* 11 h. 39 m. 4·81 s. E.

Major Palmer's result, it will be seen, is identical to within a hundredth of a second of time with the value which has been obtained from Captain Stokes's chronometric work when the most recently accepted longitude for Sydney Observatory is used. On the other hand, the results deduced from Captain Carkeek's and Messrs. Thomson and Jackson's observations seem at first sight a good deal out of line with all the other determinations. They were consequently not taken into account in deciding upon the longitude to be used for the purposes of the time-service. But Major Palmer showed in his report some four years later that Messrs. Thomson and Jackson's determination was susceptible of treatment which placed it in a different light. Messrs. Thomson and Jackson, in reducing their observations, had not taken into account the errors of the moon's tabular place. Major Palmer pointed out that the average of these errors for the days on which the moon was observed at Rockyside and the Hutt was about 0·25 s., which would probably cause an error of between + 6 s. and + 7 s. in the resulting longitude; † therefore Messrs. Thomson and Jackson's corrected longitude of the Observatory might be taken approximately as 11 h. 39 m. 9 s. E. This differs from the ultimately accepted longitude by less than 4 s., very little more than the error (3·29 s.) which shortly before this had had to be recognised in the absolutely determined longitude of Sydney Observatory. The problem of exactly ascertaining a longitude by observation is notoriously one of extreme practical difficulty; and Messrs. Thomson and Jackson's result, when subjected to this revision by Major Palmer, showed that their long and patient series of observations had been carried out with much skill and care, and was an honourable and worthy piece of work. The details of Captain Carkeek's calculations are not available, as they were accidentally destroyed many years ago by fire.

To sum up, it will be seen that all the foregoing determinations may be arranged in two groups—one with a value of about 11 h. 39 m. 9 s., and the other with a value of about 11 h. 39 m. 5 s. The former of these approximate values was practically known as long ago as 1874 to be erroneous; the latter by the same year was believed to be correct, and two years later was known to be correct, on the assumption that Sydney's longitude was reliable. Sydney's 1903 value differs by only about 1 s. from its 1874 value; so that Dr. Hector

* For details of Major Palmer's work see his report to Government, Appendix to Journals of House of Representatives, H. No. 6, 1876.

† See Loomis's "Practical Astronomy," p. 316 (seventh edition).

was a true prophet when in 1874 he expressed the belief that the "probable true longitude of Wellington Observatory" was 11 h. 39 m. 5·89 s.* Of course, it would be rash to say that no future revision may be necessary; but we seem warranted in thinking that any correction which may be called for will be but trifling.

But although the longitude was thus corrected so many years ago, the old value of 11 h. 39 m. 9 s. has up to the present time continued to be used by the Admiralty as the basis of its charts of New Zealand; consequently all positions in the colony as shown on these charts (with the exception of one sheet to be presently mentioned) are out in longitude to the extent of between $3\frac{1}{2}$ s. and 4 s. of time, or something under a mile. In view of the smallness of this error (which would not be a source of any danger to navigators), the Admiralty has no present intention of altering its charts. There are fifteen sectional charts of the coasts of the colony, besides many sheets of individual ports and of special anchorages; and to amend the longitudes on all of these would entail much expense in erasing lines on the plates and in regraduating the charts. Seeing, then, that this old longitude has been retained on the charts, it has also heretofore been retained as the working longitude of the Observatory in computing time for general and navigation purposes,† as it has been judged highly convenient to have the time-service basis identical with the chart basis so long as there seemed any chance that the amended value of the longitude might be open to further revision.

A Board of Longitude was appointed by the New Zealand Government on the 8th July, 1869, to report upon the longitude of Wellington and of other parts of the colony in relation to the initial meridian of Wellington. The Board consisted of Dr. Hector (Chairman), the Rev. A. Stock, Mr. Henry Jackson, Chief Surveyor of the Province of Wellington, and Mr. G. A. Woods, Colonial Marine Surveyor. After going into the question thoroughly, and conferring with Mr. Ellery, Government Astronomer of Victoria, the Board reported‡ in favour of adopting provisionally the chart longitude, instead of keeping the question open longer for the sake of any small error which might ultimately be ascertained. A similar view was expressed by Major Palmer in his 1875 report, and that gentleman sug-

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* Trans. N.Z. Inst., vol. vii., p. 504.

† But of course the amended longitude has been used for scientific purposes which have called for nice accuracy—such as the observations of the transits of Venus in 1874 and 1882.

‡ Appendix to Journals of House of Representatives, D.-No. 27, 1870.

gested that no change should be made until by means of the then projected submarine cable a telegraphic longitude-difference should have been obtained between New Zealand and Sydney or Melbourne.

The frequent corrections which have been found necessary in Sydney's assumed longitude since then have caused the change to be postponed longer than was originally contemplated. But circumstances now seem favourable for making it. The last alterations in the longitudes of Sydney and Melbourne were announced in the "Nautical Almanac" for 1898 (published in November, 1894); and as these were based on very careful telegraphic determinations by observers at Greenwich, Sydney, and Melbourne, they seem likely to be practically final. Moreover, the Admiralty has in one case used the latest longitude in compiling a chart.

On the sheet to which I have referred as forming an exception to the others—viz., the large-scale chart of Port Nicholson (No. 1423)—the longitude is given as 174° 46′ 20″, equivalent to 11 h. 39 m. 5·3 s. The Hydrographer to the Admiralty, in a letter written by him to Sir James Hector on the 1st December, 1902, explains that this determination (which was the one given in the report of the Australian Telegraphic Determination of Longitudes, 1886) was adopted by the Admiralty in 1890, and that, although it has not been considered necessary in the interests of navigation to alter the existing coast charts, the value 11 h. 39 m. 5·3 s. will be the initial point of any rearrangement which may ultimately be made in the Admiralty charts. He agrees that, under the circumstances (the discrepancy being so small), the determination of the Admiralty to retain the old longitude on the majority of the charts need be no further bar to our "adopting the quantity which is at present considered to be the most correct." The value given on the large-scale chart (No. 1423) is that obtained from Mr. Russell's and Mr. Adams's telegraphic work in 1883; and as this differs by only 0·2 s. from the value deduced from Mr. Russell's and Archdeacon Stock's telegraphic interchange in 1876 the way is now clear for using 11 h. 39 m. 5·3 s. as the standard longitude for computing New Zealand mean time from observations taken at the Observatory.

A similar small error occurs in the longitudes given in the Survey Department's land maps of the colony. These longitudes are based on Mr. Thomson's determination of the longitude of Rockyside (as amended in the manner above explained); consequently the values are at present practically identical with those shown in the charts. I understand, however, that the Surveyor-General purposes taking advantage of an intended reissue of the Department's maps to

revise the longitudes on the basis of Mr. Russell's and Mr. Adams's corrected determination.*

A Note on the Universal Time Question.

The references in the foregoing paper to universal or standard time seem to render it advisable to add some particulars which may possibly be of interest to those members who have not already made themselves acquainted with the history of that scheme. For the substance of the following note I am indebted to articles which have appeared during the past few years in "The Observatory" and in "The Geographical Journal," and also to an excellent little American book entitled "A Laboratory Manual in Astronomy," published in Boston recently by Miss Mary E. Byrd, Director of the Observatory of Smith College.†

It seems to be uncertain who first suggested a universal time system. As I have mentioned already, the scheme was first heard of in America, where it was forced upon the attention of the railway authorities by the inconvenience caused by a chaotic time-reckoning on the great railway-lines of the continent. In 1870 Professor C. Dowd published his pamphlet advocating in effect the system which was afterwards adopted, except that he suggested Washington, not Greenwich, as the initial meridian. Professor Benjamin Pierce also claims to have originated the suggestion; and possibly there may be other rivals of Professor Dowd's for pioneer honours in this matter. The movement soon took definite shape. It was favoured by various railway authorities and public societies—*e.g.*, the American Meteorological Society and the Society of Civil Engineers—and in particular the Canadian Institute was energetic in agitating the question. The subject was discussed at the Geographical Congress at Venice in 1881 and at the Geodetic Conference in Rome in 1883.

In the following year (1884) a representative body called the Prime Meridian Conference met at Washington. It consisted of delegates from twenty-seven nations, and after full discussion it passed several resolutions which were intended as suggestions to the civilised Governments of the world. These suggestions included "the adoption of a universal day, which should not interfere with the use of local or other time; that it should be a mean solar day beginning at mean midnight of the initial meridian, the hours to be counted from zero up to twenty-four, and that the initial meridian

* Viz., 11 h. 39 m. 6·52 s. for Mount Cook Observatory, which was 1·21 s. east of Wellington Observatory.

† Ginn and Co., Boston, 1899.

should be that of Greenwich"; also that "longitude should always be counted from this meridian in both directions up to 180°, east longitude being *plus* and west longitude *minus*"; and finally, that "the astronomical day should begin at mean midnight."

There were therefore three distinct proposals before the Conference—(1) "The change of the astronomical day [the astronomical day at present begins at midday, not at midnight]; (2) the use of a universal day; (3) the reckoning of the hours from 0 to 24 instead of in two periods of twelve each."*

The first of these proposals has not been adopted generally, as it has been felt that it would involve too much trouble and expense in the rearrangement of astronomical ephemerides. The only work of the sort in which the suggestion has so far been acted on is the "Annuaire" of the Paris Bureau des Longitudes, which made the change in the ephemeris for 1900.†

The second proposal (that for a universal day) has been found to be in advance of public opinion, and it has therefore been adopted merely in the modified form of standard times governed by hour meridians,‡ the minutes and seconds being everywhere the same as at Greenwich (except, as already explained, in the cases of those countries which have compromised by taking the odd half-hour). The proposal to accept Greenwich as the initial meridian did not at first find favour with some nations, and it was suggested that the meridian either of Jerusalem or of some obscure island or other not belonging to any great power should be chosen instead. Ultimately, however, it was recognised that the meridian of Greenwich was in every way the most suitable, and those nations which have taken up the reformed system have been content to set their clocks on the basis of the Greenwich reckoning.

The third idea (that of having a twenty-four-hour dial) has been realised on part of the Canadian Pacific Railway and on some other railways in America, and it has also been given effect to in Italy, in Switzerland (?), in Belgium, and in Spain. Many people claim (and with apparent reason) that a great simplification of railway time-tables is effected when the letters "a.m." and "p.m." are got rid of.

The following is a list of the countries which have adopted

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* "The Observatory" for February, 1901.

† *Ibid.*

‡ The basis of the system being that for $7\frac{1}{2}°$ of longitude on either side of a central meridian one time only shall be kept.

the universal time system, with the hour meridian selected in each case :—*

	Date of Adoption.
Greenwich Time—	
Great Britain.	
Belgium	1892.
Holland	1892.
Spain	1901.
1 h. fast on Greenwich—	
Germany	1893.
Italy	1893.
Denmark	1894.
Switzerland	1894.
Norway	1895.
Austria (railways).	
$1\frac{1}{2}$ h. fast on Greenwich—	
Cape Colony	1892.
Orange River Colony	1892.
Transvaal	1892.
2 h. fast on Greenwich—	
Natal	1895.
Turkey (railways).	
Egypt	1900.
8 h. fast on Greenwich—	
West Australia	1895.
9 h. fast on Greenwich—	
Japan	1896.
$9\frac{1}{2}$ h. fast on Greenwich—	
South Australia	1899.
10 h. fast on Greenwich—	
Victoria	1895.
New South Wales	1895.
Queensland	1895.
$11\frac{1}{2}$ h. fast on Greenwich—	
New Zealand	1868.
5 h., 6 h., 7 h., and 8 h. slow on Greenwich—	
United States and Canada ...	1883.

The United States and Canada are divided approximately into four territories by the meridians $82\frac{1}{2}°$, $97\frac{1}{2}°$, and $112\frac{1}{2}°$, and the times kept within these territories are as above, the 5 h. time being called "eastern time," the 6 h. time "central time," the 7 h. time "mountain time," and the 8 h. time "Pacific time."† The boundary-lines between these terri-

* From "The Observatory" for February, 1901, and July, 1901, and Miss Byrd's "Laboratory Manual in Astronomy."

† There is also supposed to be a time territory 4 h. fast on Greenwich, with central meridian 60°, but it is practically little used. The name given to it is "intercolonial time."

tories are not, of course, geometrically drawn meridian lines, but are lines which bend to suit the practical requirements of the districts concerned, much after the fashion in which boundaries between counties or States are drawn on ordinary maps (see the frontispiece to Miss Byrd's book).

In a pamphlet published in 1888* Dr. Robert Schram, of Vienna, threw out the suggestion that when all the twenty-four-hourly standards shall be in actual use it will be important to have a name for each which will be an easy guide to its position in the earth's circumference. The letters of the alphabet were to be used for this purpose; but as people would not probably care to speak of G time, or L time, or Z time, Dr. Schram's idea was that each time section should be called by the name of "a geographical point, so chosen that it begins with the letter representing this section. The place of the letter in the alphabet would indicate the longitude of the section's mean meridian expressed in hours, and would at once give in hours the difference between" standard time and Greenwich time. He proposed the Latin alphabet in its older form, containing twenty-three letters (the letters J, U, and W of the modern alphabet being rejected). "The un-Latin letter U would be used for the zero value—*i.e.*, Greenwich time—which would so retain its appropriate name, 'universal time.'" There would thus be "*A*dria time, "*B*alkan time," and so on. Under this nomenclature the time section falling to New Zealand would be called "Loyal time," the assumption being that New Zealand would adopt the 11 h. meridian, which passes near the Loyalty Islands, to the east of New Caledonia. This ingenious, if slightly fanciful plan, however, does not seem so far to have been seriously entertained.

The gain effected by the extensive adoption of the standard system has been very great, even though in some cases local or other time has continued to be used alongside of the new reckoning.

In the "Geographical Journal" for February, 1899, Professor John Milne, the eminent seismologist, gave a long list, as complete as he had been able to compile it, of the times kept all over the world. The variety was bewildering, and an inspection of the list compelled one to recognise the need for something better adapted to modern requirements.

There are still a good many parts of the world which remain to be converted to the international system, but the

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* See article "The Actual State of the Standard Time Question," by Dr. Robert Schram, in "The Observatory" for April, 1890, in which Dr. Schram gives an account of the nomenclature proposed in his previously published pamphlet.

prospects for the future are good. Always with the reservation that here and there a country or province may find it advisable to adopt the South African and New Zealand half-hour compromise, we may, in the enthusiastic words used by Dr. Schram over twelve years ago, but with a better hope of early realisation than was justifiable then, say that "very soon the system created by American energy will have conquered the globe, and the Greenwich minute and second will regulate the world's clocks."

The following is a list of the parliamentary documents and of the papers in the "Transactions of the New Zealand Institute" consulted in the preparation of the above paper :—

(A.) *New Zealand Mean Time.*

"Transactions of the New Zealand Institute," vol. i., p. 48 (1868), (second edition, p. 451): "On New Zealand Mean Time," by James Hector, M.D., F.R.S.

New Zealand Gazette, Saturday, 31st October, 1868: Notification of Adoption of New Zealand Mean Time.

(B.) *Longitude of Observatory.*

Appendices to the Journals of the House of Representatives :—

Vol. iii., 1870, D.–No. 27: Report of the Board of Longitude.

Vol. iii., 1870, D.–No. 39: Correspondence relative to the Establishment of an Observatory.

Vol. ii., 1871, G.–No. 23: Report of Messrs. J. T. Thomson and Henry Jackson on the Telegraphic Measurement of the Difference of Longitude between Wellington and Otago.

Vol. ii., 1876, H.–No. 6: Report of Major H. S. Palmer, R.E., on various Telegraphic Differences of Longitude.

Vol. ii., 1876, H.–No. 6A: Report on Mr. H. C. Russell's and Archdeacon Stock's Determination of the Difference of Longitude between Sydney and Wellington.

"Transactions of the New Zealand Institute" :—

Vol. iii., p. 82 (1870): "Abstract of Paper by Mr. Henry Jackson on the Longitude of the Hutt Observatory."

Vol. vii., p. 502 (1874): "Memorandum on the Longitude of Wellington Observatory," by Captain Nares, R.N., with covering letter by Dr. Hector.

Vol. viii., p. 441 (1875): "On the Longitude of Wellington," by J. T. Thomson.

Vol. ix., p. 217 (1876): "On the Longitude of Wellington Observatory," by Ven. Archdeacon Stock, B.A.

Art. LVI.—*The Molecular Complexity of the Fatty Acids and their Derivatives in Phenol Solution.*

By P. W. Robertson, Sir George Grey Scholar, Victoria College.

Communicated by Professor Easterfield.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

Plates XLVIII. and XLIX.

Phenol, in spite of certain drawbacks, is a popular solvent for the determination of the molecular weight of compounds by the well-known Raoult's method. Not only is it cheap and easy to obtain in a pure state, but it also has a convenient melting-point (41°). Further, it has a large molecular depression, and the magnitude of this quantity increases the accuracy of the determinations. Indeed, Easterfield and Bee* have shown that results of the required accuracy can be obtained by the use of a common thermometer and a test-tube.

At the proposal of Professor Easterfield I examined the association of water in phenol solution. From this I set about examining other compounds; my experiments with the fatty acids I propose to describe in the following communication.

First, however, I shall consider shortly the main points in the history of the cryoscopy of phenol. Raoult in his historical researches gave the value of the molecular depression as 67·5. In 1890 Eykman altered the value to 72. With a view to clearing up this apparent discrepancy, Juillard and Curchod† investigated the question, and came to the conclusion that the compound has two distinct values, 76 and 68·5, for the so-called constant. The reason of this is not far to seek, for the value 68 was obtained for associating compounds—*e.g.*, water, alcohols, and acids—while the higher number resulted when substances known to be normal were employed. The experiments below, however, show that even for one class of organic compounds the results for the value of the molecular in dilute solution (when the freezing-point is depressed 1°) vary from 82 to 64—*i.e.*, nearly 25 per cent.

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* Trans. N.Z. Inst., 1901, 497.

† Bull. Soc. Chim. [3] 6, 237.

on the mean. Van't Hoff's law, of course, only applies to infinitely dilute solutions, but even then the results appear to be little or no more in agreement. Thus, for a fall of 0·2° stearic and lauric acids give by a slight interpolation the numbers 81 and 66, and these acids are both normal fatty acids.

Calculating the results from Van't Hoff's equation, $D = \cdot 02T^2/w$, where T is the melting-point on the absolute scale and w the latent heat of fusion, we arrive at the result 69. Using, on the other hand, the expression proposed by myself,* $D = \cdot 0087\ MT/\sqrt[3]{\frac{M}{d}}$ (for mono-derivates of benzene), the value of D becomes 54, which is abnormally low.† The possibility here presents itself, however, that this irregularity may have some connection with the varying values obtained for the molecular depression.

About 1897 a large number of interesting cryoscopical researches were carried on by the Italian school of chemists. Paternò examined, among other solvents, the behaviour of phenol for many compounds, his aim apparently being to examine substances of all types and not to confine himself to any one particular group. From his observations he concludes that phenol is different from most solvents in that there is a tendency for the molecular weights to decrease with the concentration, whilst in general the reverse is found to be the case.

The apparatus used in these experiments is essentially that described by Easterfield and Bee,‡ only the stirrer is of glass and a side tube is added in order to introduce the substance under investigation more conveniently. Of course, a more accurate thermometer is employed: the instruments used in the investigation could be accurately read to a hundredth of a degree.

The mode of experimenting is as follows: 10 to 20 grams of phenol are weighed into the apparatus and two readings of its freezing-point taken. Enough of the foreign substance is now introduced either from a small weighing-tube if a solid or from a Sprengel pipette in the case of it being a liquid to cause a depression of about three-quarters of a degree. After

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* Trans. N.Z. Inst., 1901, 501.

† Other phenolic compounds give concordant results with those obtained by actual experiment. Thus for the following substances the calculated values are given, the equation being for multi-substituted benzenes, $D = \cdot 0078\ MT/\sqrt[3]{\frac{M}{d}}$

Parabromphenol	99 (experimental 98)
Orthonitrophenol	74 („ 74)
Thymol	70 („ 74)

‡ Trans. N.Z. Inst., 1901, 497.

complete solution a double determination of the temperature of solidification is made, and this process is repeated six or seven times if the solubility permits it. When the dissolved substance is only slightly soluble it is introduced in smaller quantities, and consequently in such cases the accuracy cannot be so great.

Besides the error of temperature-determination, which does not exceed 1 per cent., there are several others of more or less moment. Phenol is slightly hygroscopic; but, as in all cases the conditions are practically the same, this source of error, which at the most is only slight, can hardly influence the results. Perhaps the most serious error is that caused by the non-homogeneity of the solution which is being experimented with. Thus, the solute, especially if a liquid, may stay on the thermometer in small quantities above the solution; the solvent also has a tendency to climb up the stirrer and thermometer and sublime to the upper parts of the apparatus. The errors in weighing can be entirely neglected. But in a series of determinations these errors tend to disappear or neutralise one another, and for this reason the rate of association is a more accurate result than the initial molecular depression. Moreover, traces of impurity will, of course, affect the latter, but seem to have little influence on the former. Nevertheless, every effort was made to obtain the material as pure as possible, and different samples were employed where conveniently possible. As an example of the accuracy obtainable in the work I may cite the case of lauric acid. Three determinations gave the following numbers for the rate of association (depression 5°): 58 per cent., 62 per cent., 60 per cent. (different sample of phenol).

Most of the fatty acids employed in the investigation were from Merck; acetic acid was frozen several times, and the lower members were fractionated before use. Normal valeric and methylethyl acetic acids were synthesised from ethyl malonate; but, owing to the small quantities at my disposal, their purity cannot be so fully guaranteed. Lauric and stearic acids showed their purity by their melting-points. A number of the other acids were also from Merck. Professor Easterfield kindly placed his own private stock of preparations at my disposal. Among others I prepared the following acids: bromacetic, cinnamic, ethylmalonic, brombutyric, oxydiphenylacetic, nitrosovaleric, dibrommethylsuccinic, anilidoacetic, toluidoacetic, phenylanilidoacetic, amidoacetic, acetamidoacetic, mesaconic, adipic, and phenoxyacetic, all of which were used in the investigation.

In order to show clearly the method of calculating the results I will give one example in full; in the other cases the final results alone are tabulated.

TABLE I.

*Stearic Acid** (molecular weight, 284).

1. Weight of phenol = 10·6 grams.

Fall in F.P. (d).	Weight of Acid.	Molecular Depression.
·59°	·2290	76·5°
·395°	·1736	68·5°
·56°	·2906	58°

i.e., association increases $\frac{1}{76 \cdot 5}-\frac{1}{58}$ for a fall of 1·07° $(\frac{\cdot 59}{2}+\cdot 395+\frac{\cdot 56}{2})$ ∴ increases 147 per cent. for a fall of 5°.

2. Weight of phenol = 14·5 grams.

Fall in F.P. (d).	Weight of Acid.	Molecular Depression.
·40°	·2168	76°
·31°	·1888	67°
·22°	·1454	62°
·53°	·3594	60°

i.e., association increases $\frac{1}{76}-\frac{1}{60}$ for a fall of ·99° ∴ increases 135 per cent. for a fall of 5°. Mean increase, 141 per cent.

The molecular depression is calculated from the equation $D=\frac{284 \times d \times W}{100m}$ where W and m are the weights of the phenol and stearic acid respectively.

The experimental results are given in detail in Table II. A number of these results are represented graphically, the molecular depression being plotted against the concentration (see Plates XLVIII. and XLIX.). The different acids will be considered under the following heads:—

1. The fatty acids.

2. The mono-, di-, and tri-substituted acetic acids where the substituents are phenyl, alkyls, and halogens.

3. The dicarboxylic acids.

4. Oxy and nitroso acids.

5. The substituted amido acids.

6. Acids whose molecular depression increases with the concentration.

1. (*a*.) *The Normal Fatty Acids (Nos. 1–8, Table II.)*.—The rate of association alternately increases and diminishes as the series is ascended, each of the even members associating more rapidly than either of the two contiguous odd acids. If alternate members are considered—*e.g.*, the even—it is found that the rate slowly decreases, reaches a minimum probably at C_6, and then increases extremely rapidly. From considerations in the next paper, where cases of this nature

* Owing to its slight solubility a depression of only about 1½° could be reached.

are discussed, it appears probable that the acids with an odd number of carbon atoms will behave in the same way. This peculiar behaviour is shown by several of the properties of the fatty acids, including their melting-points and the differences of their boiling-points.

Biltz found nothing of this nature when he determined the rates of association of the alcohols in benzene solution. It is noteworthy, however, that neither the melting-points nor the differences of the boiling-points of these compounds show a behaviour like that of the aliphatic acids.

TABLE II.

Acid.	Class considered under.	Percentage Rate of Association for Depression of 5°.	Molecular Depression for 1°.
1. Acetic (C_2) ...	1	33	71
2. Propionic (C_3) ...	1	18	70
3. Butyric (C_4) ...	1	20	69
4. Valeric (C_5) ...	1	16	67·5
5. Hexoic (C_6) ...	1	18	67
6. Heptoic (C_7) ...	1	13	66
7. Lauric (C_{12}) ...	1	60	64
8. Stearic (C_{18}) ...	1	141	70·5
9. Isovaleric ...	1	25	72·5
10. Methylethylacetic ...	1 and 2	12	72
11. Chloracetic ...	2	20	71
12. Bromacetic ...	2	17	72
13. Brombutyric ...	2	11	77
14. Phenylacetic ...	2	20	69
15. α Chlorphenylacetic	2	4	71·5
16. Trichloracetic ...	2	2·5	68
17. Ethylmalonic ...	3	44	72
18. Methylsuccinic ...	3	67	66
19. Sebacic	3	23	70
20. Dibrommethylsuccinic	3	16	...
21. Lactic	4	23	...
22. Mandelic	4	32	70
23. Benzilic	4	7	69·5
24. Oxydiphenylacetic ...	4	5·5	73
25. Nitrosovaleric ...	4	50	63·5
26. Anilidoacetic ...	5	24	69·5
27. Hippuric	5 and 6	− 20	72·5
28. Levulinic	6	− 2	82

The results obtained for the initial molecular depression, on the other hand, do not show this wavy character, but diminish regularly for some distance, apparently reaching a minimum value in the neighbourhood of lauric acid, and then increasing at about the same rate, or perhaps slightly faster. The rate of association was shown to increase much more quickly than it diminished for the lower members.

1. (*b.*) *The Isomeric Fatty Acids.* — When the chain branches beyond the α carbon the rate of association increases: this is shown in the case of isovaleric acid thus—

Butyric.

$$CO_2H \cdot CH_2 \cdot CH_2 \cdot CH_3$$

20

Isovaleric.

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \Big> CH \cdot CH_2 \cdot CO_2H$$

25

Normal Valeric.

$$CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CO_2H$$

16

The numbers placed beneath the acids are their rates of association. The influence of such a grouping probably becomes less as it is further removed from the carboxyl.

In the acids with one of the α hydrogens replaced by an alkyl group, such as methylethylacetic acid, the rate of association is found to be less than that of the corresponding normal acid. That this behaviour is general is confirmed by the results obtained for other disubstituted acetic acids, which are discussed under 2.

Scanty as this evidence is, there is presented a simple method for discriminating the isomers of higher members. Compared with chemical methods it possesses two great advantages—namely, quickness of execution, and the small quantity of material required for the experiment.

2. (*a.*) *Monosubstituted Acids.*—In these acids the halogens, methyl, ethyl, and phenyl have practically the same influence, the numbers varying from 17 in the case of bromacetic to 20 for phenylacetic acid. Thus the negative groups behave like the positive; if the substituents are of the same nature the heavier group appears to have the greater influence—*e.g.*, in the case of chlor- and brom-acetic acids, the values of which are 20 and 17. On the other hand, methylacetic acid associates more slowly than ethylacetic.

2. (*b.*) *Disubstituted Acids.* — Dichloracetic acid unfortunately decomposes in the presence of phenol, giving a solution with a beautiful fluorescence, transmitting light of greenish hue and reflecting red. The only dialkyl acid examined was methylethylacetic, which associates at the rate of 12 per cent.—*i.e.*, slower than either of the acids from which it is derived.

Propionic.
$CH_3 \cdot CH_2 \cdot CO_2H$
18

Butyric.
$CH_3 \cdot CH_2 \cdot CH_2 \cdot CO_2H$
20

Methylethylacetic.
$CH_3 \cdot CH \cdot CO_2H$
$\quad\quad\quad\; |$
$CH_3 \, . \, CH_2$
12

On replacing the methyl in this compound by bromine the rate of association remains practically the same: this was also found in the case of bromacetic acid.

Propionic.	Bromacetic.
$CH_3 \cdot CH_2 \cdot CO_2H$	$Br \cdot CH_2 \cdot CO_2H$
18	17
Methylethylacetic.	Bromethylacetic.
$CH_3 \cdot CH_2 \cdot CH(CH_3) \cdot CO_2H$	$CH_3 \cdot CH_2 \cdot CHBr \cdot CO_2H$
12	11

Whereas the phenyl group has an effect approximately equal to an alkyl or a halogen in the monosubstituted acids, its influence is strongly normalising in the diacetic acids.

It is interesting to compare the rates of association of the following acids :—

Phenylacetic.	Butyric.
$C_6H_5 \cdot CH_2 \cdot CO_2H$	$C_2H_5 \cdot CH_2 \cdot CO_2H$
20	20
Chlorphenylacetic.	Chlorethylacetic.
$C_6H_5 \cdot CHCl \cdot CO_2H$	$C_2H_5 \cdot CHCl \cdot CO_2H$
4	(12)

The number in brackets is calculated by analogy from the similarly constituted brombutyric acid.

Diphenylacetic acid also probably associates very slowly, as its oxy-derivative shows the low value of 5·5. Thus we see that when one of the groups in a disubstituted acetic acid is a phenyl the acids associate much less rapidly than the compounds with alkyl or halogen groups. The explanation of this perhaps lies in the stereo-chemistry of the phenyl in the molecule. At any rate, it renders the *a* hydrogen which causes the association in these acids practically inactive.

It is interesting to note that all the acids of this type have a high value for the initial molecular depression.

2. (*c*.) *Trisubstituted Acids.*—As would be expected, trichloracetic acid possesses a rate of association of only 2·5 per cent. The only other acid of this class in the list is benzilic acid, $(C_6H_5)_2 \cdot COH \cdot CO_2H$, whose association (7 per cent.) is no doubt increased owing to the action of the hydroxyl group (see under 4).

3. *The Dicarboxylic Acids.*—These acids, as well as the tricarboxylic acids, with their halogen and oxy derivatives, are

characterized by their sparing solubility. On introducing an alkyl group, however, the compounds are rendered much more soluble, and can therefore in most cases be examined (see under "Solubilities," p. 463).

Of the groups examined, carboxyl exerts, in general, the most influence, always increasing the rate of association of the monocarboxylic acid from which it is derived. The magnitude of the change is clearly seen in the case of the isomeric acids—ethylmalonic and methylsuccinic.

Butyric.
$CH_3 \cdot CH_2$
$CH_2 \cdot CO_2H$
20

Ethylmalonic.
$CH_3 . CH_2$
$CH(CO_2H)_2$
44

Methylsuccinic.
$CH_3 \cdot CH \cdot CO_2H$
$CH_2 \cdot CO_2H$
67

Isobutyric.
$CH_3 \cdot CH \cdot CO_2H$
CH_3
(10–14)

In ethyl malonic the two carboxyls are attached to an isocarbon atom, but in methylsuccinic acid one is united to an iso and the other to a carbon united to two atoms of hydrogen. As would be expected, the association is more rapid in the latter case. In sebacic acid the carboxyls are much further separated, and the mutual influence of the two groups is thus less noticeable.

Nonylic.	Sebacic.
$H(CH_2)_8 \cdot CO_2H$	$CO_2H \cdot (CH_2)_8 \cdot CO_2H$
(11)	23

If the α hydrogens are replaced, the mutual effect of the carboxyls is much diminished. This is seen in the case of dibrommethylsuccinic acid, which associates only at the rate of 16 per cent.

Methylsuccinic.	Dibrommethylsuccinic.
$CH_2 \cdot CO_2H$	$CBr_2 \cdot CO_2H$
$CH_3 \cdot CH \cdot CO_2H$	$CH_3 \cdot CH \cdot CO_2H$
67	16

Oxy and Nitroso Acids.—In phenol solution the molecular depressions of hydroxyl compounds tend to increase with rising concentration; but a hydroxyl group increases the association of an acid. From this it seems probable that there is some mutual influence between the two groups, as a diminution of the rate of association is to be expected. This being so, there is reason to expect that the hydroxyl would have less and less effect the further it is removed from the carboxyl group.

Of the acids examined it is interesting to compare lactic and mandelic with the compounds from which they are derived.

Propionic.	Lactic.
$CH_3 \cdot CH_2 \cdot CO_2H$	$CH_3 \cdot CH(OH) \cdot CO_2H$
18	23
Phenylacetic.	Mandelic.
$C_6H_5 \cdot CH_2 \cdot CO_2H$	$C_6H_5 \cdot CH(OH) \cdot CO_2H$
20	32

The greater magnitude of the increase in the case of mandelic acid is especially noteworthy when we remember that all the disubstituted acetic acids containing a phenyl radicle are characterized by their extremely low rate of association. That the high value in the case of mandelic acid is due to the remaining α hydrogen is evident from the fact that benzilic acid, in which this hydrogen is replaced by phenyl, has the low value of 7 for its rate of association. Thus it seems that the oxy group protects the hydrogen from the normalising influence of the phenyl; other groups, however, have quite a different effect. Thus—

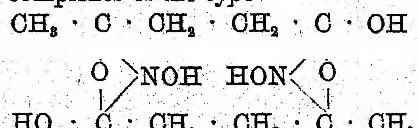
Chlorpropionic.	Chlorphenylacetic.
$CH_3 \cdot CHCl \cdot CO_2H$	$C_6H_5 \cdot CHCl \cdot CO_2H$
(13)	4
Lactic.	Mandelic.
$CH_3 \cdot CH(OH) \cdot CO_2H$	$C_6H_5 \cdot CH(OH) \cdot CO_2H$
(23)	32

When the hydroxyl occurs in the benzene nucleus of a substituted fatty acid its influence is only slight. This is shown for othooxydiphenylacetic, which associates at about the rate that we should expect in the case of diphenylacetic acid.

Nitrosovaleric acid possesses the constitution

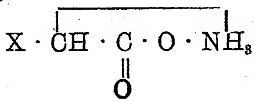
$$CH_3 \cdot \underset{\underset{NOH}{\|}}{C} \cdot CH_2 \cdot CH_2 \cdot CO_2H$$

It associates very rapidly, but it differs from most of the acids with high association numbers in the fact that it possesses a very low value for the initial molecular depression. Again, it is the only acid of which the rate of association clearly diminishes with the concentration. (See Plate XLIX.) Hence it seems probable that the associating groups disappear in the process of association. This favours the possibility of the formation of complexes of the type



If, on the other hand, two molecules united through the nitroso groups a dibasic acid would be formed, and then the association should be expected to increase with the depression of freezing-point.

5. *Substituted Amido Acids.*—The α amido acids are characterized by extreme insolubility in phenol. First it was thought that this was due to the internal combination of the acid and basic parts of the molecule, the constitution of these acids then becoming



This, however, is rendered improbable for the following reasons:—

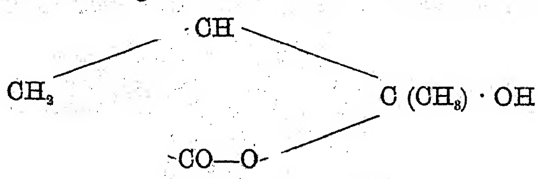
(*a.*) In the case of amidosuccinic acid one carboxyl group should become neutralised, forming a monocarboxylic acid, which would then dissolve. This substance, however, is extremely insoluble.

(*b.*) Anilidoacetic acid has a considerable rate of association, whereas if the carboxyl group were neutralised this would hardly be expected.

Hippuric (*i.e.*, benzoylamidoacetic) acid is characterized by its great rate of negative association. (It must be remembered, however, that the total depression is only a little above 1°.) The slight solubility cannot be the cause (for anilidoacetic-acid associates). It is well worth remarking, however, that the saturated solutions of these two acids have the same molecular depression, 71, which is about the mean value for the so-called constant.

6. *Acids whose Molecular Depression increases with the Concentration.*—Levulinic acid gives the abnormally high value 82 for the molecular depression. This, however, is probably correct. The acid obtained by fractionation under reduced pressure gave the value as 75. On solidifying this in a freezing mixture and separating the solid from the liquid the former gave the mean value 82.

In 1887 Bredt* gave the constitution of levulinic acid as



* "Annalen," 236, 225.

This alcoholic constitution is, I believe, at present not generally accepted, but it is probable that in phenol solution the molecules join up with themselves to give an alcohol, for (*a*) the alcohols have a molecular depression increasing with the concentration; (*b*) the alcohols have a high initial molecular depression.

Hippuric acid has already been discussed: it possesses a resemblance to levulinic acid only in that there exists a carboxyl group in the molecule.

The Connection between the Rate of Association and other Properties of the Acids.

Sudborough and Lloyd* have determined the rates of esterification of a number of substituted acetic acids in the presence of hydrochloric acid. The qualitative agreement between their results and those in Table II. is remarkable. The comparison is shown in the following table:—

Table III.

Acid.	Esterification Constant.	Rate of Association.
Acetic	3·661	32
Propionic	3·049	18
Chloracetic	2·432	20
Phenylacetic	2·068	20
Bromacetic	1·994	17
Diphenylacetic	0·0559	(4)
Trichloracetic	0·0372	2·5

For the esterification constant the numbers are given in decreasing order. With the single exception of propionic acid the values for the rate of association are in exactly the same order.

The reason of this is not far to seek. The most probable theory of esterification is due to Henry: his explanation is based on an additive hypothesis. This is what occurs with the acids in phenol solution; but in this case like molecules are added together, while in the process of esterification an unstable addition product is formed with the alcohol, and this immediately decomposes into the ester.

Looking somewhat ahead, it is to be expected that the ortho acids will associate less rapidly than their isomers, as these compounds are the most difficult to esterify. Further, the diortho substituted acids should scarcely associate at all, as, according to the well-known researches of V. Meyer and his pupils, these acids either do not form esters by this method or do so only with the greatest difficulty. Whether this supposition is true or false I hope to ascertain in the near future.

* Trans. Chem. Soc., 1899, 467.

CONNECTION BETWEEN THE MOLECULAR DEPRESSION AND THE RATE OF ASSOCIATION.

Among the normal fatty acids both constants tend to increase at the same time, though this is not absolute. The disubstituted acids tend to have a slightly higher value for the depression than the mono acids. Other regularities, if they do exist, remain hidden. Even if the acids associate at the same rate the molecular depressions may vary widely. Thus nitrosovaleric acid (rate of association 50 per cent.) has a molecular depression of 64; ethylmalonic acid, on the other hand (association 44 per cent.), gives the value of the constant as 72. Again, chlorphenylacetic and trichloracetic acids associate at the rates of 4 and 2·5, but their depression constants are 71·5 and 68. Of the seven acids whose association numbers vary between 18 and 24, all but one give molecular depressions between 69 and 71.

In spite of these minor relationships, it is clear that the conditions that influence the molecular depression are indistinct; in all probability it depends to a large extent on the spatial arrangement of the molecule in solution.

THE SOLUBILITY OF THE FATTY ACIDS AND THEIR DERIVATIVES IN PHENOL.

The following generalisations may be drawn up:—

(1.) The fatty acids are readily soluble, but the solubility becomes slight when stearic acid is reached.

(2.) All the oxy, halogen, and phenyl derivatives are readily soluble.

(3.) The polycarboxylic acids are characterized by their extreme insolubility: this applies also to their unsaturated compounds, the halogen and oxy derivatives. Their solubility, however, is much increased by the introduction of an alkyl group, the effect being smaller the greater the number of carboxyls.

(4.) The oxy derivatives of the dibasic acids are less soluble than the original acids.

(5.) Of the unsaturated dibasic acids the cis compounds are much more soluble than their isomers possessing the trans configuration.

(6.) The α amido acids are extremely insoluble; their substituted derivatives possess a slight solubility.

In the following table the differences between the freezing-points of phenol and its saturated solution are given for a number of acids. This depression is roughly proportional to the number of dissolved molecules in a saturated solution of a constant weight:—

Table IV.

Acid.	F.P. Depression of Saturated Solution.
1. Malonic	·15°
2. Succinic	·22
3. Adipic	1·3
4. Sebacic	2·1
5. Methylsuccinic	> 3
6. Ethylmalonic	> 3
7. Mesaconic	·27
8. Citraconic	> 5
9. Fumaric	·09
10. Maleic	2·3
11. Bromsuccinic	·45
12. Dioxysuccinic (tartaric)... ...	·10
13. Tetraoxyadipic (mucic)	·25
14. Amidoacetic	·08
15. Phenylamidoacetic	1·4
16. Benzoylamidoacetic	2·05
17. Amidophenylacetic	·15
18. Phenylamidophenylacetic ...	1·7
19. Amidosuccinic...	·29
20. Tricarballylic	·20
21. Isopropyltricarballylic	·38

Acids 1–4 are homologous dibasic acids: it is seen that the solubility rises with the molecular weight. Mesaconic and fumaric acids are trans acids; they are much less soluble than their isomers, citraconic and maleic acids. It is interesting to note that with these acids the compounds that most readily form anhydrides are the most soluble. This was also observed in the case of succinic and methylsuccinic acids. The addition of a methyl group increases both the solubility and the ease of anhydride formation.

Tartaric and mucic acids (12 and 13) are considerably less soluble than the acids from which they are derived (2 and 3).

In the dibasic acids the introduction of an alkyl group causes an enormous increase in the solubility. In the case of the tribasic isopropyltricarballylic acid the increase is only comparatively slight (20 and 21).

Among other insoluble di- or tri-basic acids may be mentioned oxalic, meconic, camphoric, and aconitic acids.

Summary and Conclusion.

(1.) In freezing phenol the fatty acids and their derivatives associate more or less rapidly with rising concentration.

(2.) The rates of association of the normal fatty acids alternately increase and decrease for each member. If the

even compounds alone are considered the association decreases, reaches a minimum, and then rapidly rises again. The initial molecular depression, however, steadily falls to a minimum, and then rises again after about the twelfth member.

(3.) Disubstituted acetic acids associate less rapidly than mono-derivatives. The trisubstituted acids have the smallest rate of association.

(4.) Dicarboxylic acids associate more strongly than the monocarboxylic acids.

(5.) Hydroxyl and nitroso groups tend to increase the rate of association.

(6.) The rate of association of the substituted acetic acids shows a qualitative relationship with their velocity of esterification.

(7.) The dicarboxylic and α amido acids are characterized by their sparing solubility.

In conclusion, I wish to express my thanks to Professor Easterfield for the encouragement and advice which he has given me during the course of my work.

ART. LVII.—*The Exhibition of a Maximum or Minimum in the Properties of certain Series of Organic Compounds.*

By P. W. ROBERTSON, Sir George Grey Scholar, Victoria College.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

THE aim of the following paper is to collect the various data in which a maximum or minimum is exhibited in an homologous series, and to show that in many cases the cause is due to the influence of molecular association. For the sake of convenience two main subdivisions are made: A. When the maximum or minimum is clearly seen. B. When it is hidden.

A. (1.) *When the Compounds are in the Gaseous State.*—The only example of this yet observed is described in the preceding paper. The molecular association of the fatty acids in phenol solution first increases as the series is ascended, and then, having reached a maximum, continues to decrease.

Assuming for the present that the molecular weight of acetic acid is normal when the freezing-point of its solution is depressed 1°, and that the molecular depression is inversely proportional to the amount of association, the following values are obtained for the association factors :—

TABLE I.

Acid.	No. of Carbon Atoms in Molecule.	Association Factor.
Acetic	2	1·00
Propionic	3	1·01
Butyric	4	1·03
Valeric	5	1·05
Hexoic	6	1·06
Heptoic	7	1·07
Lauric	12	1·11
Stearic	18	1·01

On the other hand, the rate of association alternately increases and decreases; thus in this case there is an intimate relationship between the attainment of maximum association and the wavy nature of a closely related property.

Generally speaking, association decreases with rise in molecular weight. This was observed by Ramsay and Shields and by Traube in the case of liquids, and is also true for the association of the fatty acids in the gaseous state as measured by their vapour densities.* An increase of molecular complexity which extends to far up the series, as in the case of the aliphatic acids in phenol, has never been previously observed.

(2.) *When the Compounds are in the Liquid State.*—Examples of this are exceedingly numerous for the rotary power of optically active compounds. Guye showed that in many cases the explanation may be given from his hypothesis of the product of asymmetry. Frankland,† on the other hand, explains the maximum or minimum in many cases as due to the association of the initial members of the series. A clear case of this is exhibited by the esters of active amyl alcohol (Guye and Chavanne). The association factor is calculated according to Traube's formula:—

TABLE II.

Ester.	[α].	Association Factor (15°).
Amyl formate ...	+ 2·01	1·08
„ acetate ...	+ 2·53	1·02
propionate ...	+ 2·77	1·00
butyrate ...	+ 2·69	0·94
„ valerate ...	+ 2·52	0·92
„ hexoate ...	+ 2·40	0·90

Here it is seen that when there is no association the values of [α] regularly increase.

* Easterfield and Robertson, Trans. N.Z. Inst., 1901, 499.
† Trans. Chem. Soc., 1899, 347.

(3.) *When the Compounds are Solids.*—(*a.*) The Melting-points of the Phenyl Fatty Acids :—

TABLE III.

Acid.	Melting-point.
Benzoic	121°
Phenylacetic	77
Phenylpropionic	49
Phenylbutyric	47
Phenylvaleric	52

Now, molecular complexity raises the boiling-point; and, in general, when the boiling-point of an isomer rises the melting-point is found to fall. Consequently, when the melting-point falls in an homologous series (a rise being expected) it may naturally be concluded that the association of the molecules becomes greater with the fall of melting-point.

(*b.*) The Solubilities of the Calcium Salts of the Fatty Acids :* In the case of the normal acids the salts increase in solubility from formate to propionate, and then decrease quickly with the increase of the number of carbon atoms. In the following table the values of the solubilities are given for the temperatures 0° and 100° :—

TABLE IV.

Salt.	Solubility (0°).		Solubility (100°).
Calcium formate	16·15	(increase)	18·40
" acetate	37·40	(decrease)	29·65
" propionate	42·80	(increase)	48·44
butyrate	20·31	(decrease)	15·85
valerate	9·82	(decrease)	8·78
hexoate	2·23	(increase)	2·57
heptoate	0·95	(increase)	1·26
octoate	0·33	(increase)	0·50
nonoate	0·16	(increase)	0·26

Near the member where the maximum solubility occurs it is found that there is alternate increase and decrease of solubility between 0° and 100°. This is comparable with the association of the fatty acids (A (1)) where the rate alternates, but the association reaches a maximum.

Lumsden states that one of the causes that determines the solubility is osmotic pressure. Now, osmotic pressure is influenced by association; so we see in this case also that there is a possibility of the cause of the phenomenon being molecular association.

B. (1.) *When the Compounds are in the Gaseous State.*—Again, the only example of this type is furnished by the fatty

* Lumsden, Journ. Chem. Soc., 1902, 350.

acids in phenol (see above, Article LVI.), whose rates of association alternately increase and decrease. If the even members alone are considered it is found that the rate slowly falls to a minimum, and then rapidly increases.

(2.) *When the Compounds are Liquids.*—(*a*.) The Boiling-points of the Fatty Acids and their Derivatives, the Ketones, Nitroparaffins, and Nitriles: If the boiling-points of the fatty acids are considered a continual increase is noticed. On taking successive differences, however, the numbers obtained are of a wavy nature. As is seen in the following table, the second set of differences decreases, reaching a minimum and then increasing again. The other series also decreases, but more slowly, perhaps reaching a minimum higher up the series.

TABLE V.

Acid.	Boiling-point.	Differences.	
Acetic	118°	23	
Propionic	141		22
Butyric	163	23	
Valeric	186		19
Hexoic	205	19	
Heptoic	224		12
Octoic	236	18	
Nonoic	254		15
Capric	269		

The same alternate rise and fall is shown if the boiling-points are taken at a pressure of 100 mm. In this case, however, the even to odd differences are smaller, and reach the minimum first, whilst at atmospheric pressure the reverse is the case.

TABLE VI.

Acid.	Boiling-point.	Differences.	
C_9	185°		17
C_{10}	202	11	
C_{11}	213		13
C_{12}	226	10	
C_{13}	236		12
C_{14}	248	9	
C_{15}	257		12
C_{16}	269	8	
C_{17}	277*		10
C_{18}	287	11	
C_{19}	298		

This behaviour of the fatty acids is probably due to the

* This boiling-point is interpolated.

association of the vapour at the boiling-point, for the following reasons :—

(1.) It is less noticeable in the case of the esters, which are only slightly associated.

(2.) The minimum is less marked when the boiling-points under reduced pressure are considered, and under reduced pressure the amount of association is reduced.

(3.) It is not exhibited by series of compounds which are associated neither in the liquid nor gaseous state, nor, on the other hand, by the alcohols which form liquid (not gaseous) molecular complexes.

Among the esters the successive differences are much more regular. In the following table the boiling-points of the methyl, ethyl, and propyl esters of the fatty acids are given :—

TABLE VII.

—	Methyl.	Differences.		Ethyl.	Differences.		Propyl.	Differences.	
Acetate ..	57·5°	22		77°	23		101°	21·5	
Propionate ..	79·5		23	100		20	122·5		21·5
Butyrate ..	102·5	25		120	25		143	24·5	
Valerate ..	127·5		22	145		22·5	167·5		18
Hexoate ..	149·5	23·5		167·5	20		185·5	21	
Heptoate ..	173		20	187·5		20	206·5		18
Ochoate ..	193	20		207·5	20		224·5		
Nonoate ..	213			227·5					

For each series the first set of differences shows a clear maximum between the esters derived from the C_4 and C_5 acids, the number being in all cases practically the same (25). The acids themselves show a maximum at the same place, although it is much less marked. In the other set of differences there is a general tendency for the numbers to decrease, but the characteristic minimum observed in the acids finds no parallel among their ethereal salts.

In general the methyl esters bear a much closer resemblance to the acids themselves than do the esters with larger alkyl radicals. This is seen, for instance, in their higher melting-point and the greater complexity of the liquid molecules. At the boiling-point such differences disappear. This is only another example showing that the boiling-point is a comparable temperature for physical data.

Much more clearly than with the esters is a similar relation exhibited by the acid chlorides. The following table is given by Henry,* who pointed out the large variations in successive differences of the boiling-points, but did not ap-

Rec. Trav. Chim., 1899, 18, 247.

pear to show the regular formation of a maximum at the number 29:—

TABLE VIII.

	Boiling-point.	Differences.	
Acetyl chloride	51–52°		
		26·5	
Propionyl "	78–80		
			21·5
Butyryl "	100–101		
		27	
Valeryl "	127–128		
			18·5
Hexoyl "	145–146		
		29	
Heptoyl "	174–175		
			20
Octoyl "	194–195		
		26	
Nonoyl "	220		

This maximum occurs in the same series as the maximum shown by the esters and the acids themselves, but one place higher. The acid chlorides also differ from the esters and the acids themselves, by the fact that the average for the set of larger differences (27) is considerably greater than the corresponding number (22) for the acids and their ethereal salts. On the other hand, a resemblance is shown to the esters' slight differences between the numbers of the same set, while this is not the case among the acids. This, then, is the true test for the magnitude of the molecular complexity of the gaseous molecule at the boiling-point.

Acids of the oxalic series tend to decompose when heated, consequently their boiling-points cannot be determined under the ordinary conditions. Krafft,* however, has determined the boiling-points of some of the higher members under reduced pressure. The results show the usual waviness, but the differences are smaller than for the corresponding fatty acids under the same conditions. Hence it is reasonable to conclude that the association of the dibasic acids in the state of vapour is less than that of the fatty acids from which they are derived.†

TABLE IX.

Acid.	Number of Carbon Atoms in Molecule.	Boiling-point (10 mm.).	Differences.	Boiling-point (100 mm.).	Differences.
Adipic ...	6	205·5°		265°	
			6·5		7
Pimelic ...	7	212		272	
			7·5		7
Suberic ...	8	219·5		279	
			6·0		7·5
Azelaic ...	9	225·5		286·5	
			6·5		8
Sebacic ...	10	232		294·5	

* Ber., 22, 816.

† In phenol solution, although sebacic acid associates more rapidly than the corresponding fatty acid, the initial association of the latter is greater.

From analogy with the fatty acids it is to be expected that the esters of these acids would exhibit similar relations. But the data are too scanty and inconsistent among themselves to draw any conclusions therefrom.

The data for various aldehydes and ketones are presented in the next table, as they show a similarity to the results already obtained.

TABLE X.

Number of Carbons in Radical R.	Boiling-point of Aldehydes —R. CHO.	Differences.		Boiling-point of Ketones— R. $COCH_3$.	Differences.		Boiling-point of Ketones— R. COC_2H_5.	Differences.	
1	21°	28		56·5°	24		80·5°	22	
2	49		25	80·5		21·5	102·5		21
3	74	29		102	25		123	23	
4	103		25	127		24·5	146*		20
5	128	25		151·5	21·5		166	23	
6	153			173			190		
7	161								

* This boiling-point is interpolated.

The maximum in all cases occurs in the usual place—*i.e.*, the second member of the first set of differences. The ketones of the type R. $COCH_3$ show practically as much association as the aldehydes, thus differing from the other series of ketones, which is almost normal. The methyl esters, it will be remembered, differed largely from the acids whence they were derived; but here the alkyl radical replaces a hydroxyl hydrogen, while in the case of the aldehydes the hydrogen is joined directly to a carbon atom.

Seeing that when the gaseous molecule is associated at the boiling-point results of this nature are obtained, the nitriles and nitroparaffins ought to behave in a similar manner. That this is the case is seen from the following tables :—

TABLE XI.

	Boiling-point.	Differences.	
Aceto nitrile ..	81·5°	15·5	
Propiono " ..	97		21·5
Butyro " ..	118·5	22·5	
Valero " ..	141		13·5
Hexöo " ..	154·5	22	
Heptöo " ..	176		21
Octöo " ..	197	18	
Nonöo " ..	215		

Here, again, the maximum is observed in exactly the same place as among the acids and their esters, the aldehydes and ketones. Further, there is an exceedingly pronounced minimum in the other series; this corresponds to a similar mini-

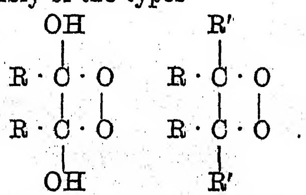
mum, though not so sudden, among the data for the acid chlorides, and to the characteristic minimum, which occurs in the next number of this series for the fatty acids.

TABLE XII.

	Boiling-point.	Differences.	
Nitromethane ...	101°		
Nitroethane	114·5	13·5	
Nitropropane ...	131		16·5
Nitrobutane	151·5	20·5	
Nitropentane ...	(150–160) ?		(8·5)
Nitrohexane	176	(16)	
Nitroheptane ...	195		19

The numbers in brackets are rendered doubtful owing to the result obtained for the boiling-point of nitropentane. The higher limit is taken as the more probable, but this cannot affect the general conclusions. This series is exactly similar to the nitriles. The changes occur in the same positions, and are perhaps a little more marked, indicating a greater molecular complexity of the gaseous molecules.*

The hydrocarbons, their halogen derivatives, the alcohols, amines, and ethers, exhibit no such behaviour. But in none of these series has any considerable association been noticed. In all the instances where the wavy character occurs there is either a carboxyl group $>C=O$ in the molecule or a nitrogen atom. In the cases of the acids and ketones the molecular complexes are possibly of the types



For monobasic acids a greater complexity has never been observed either in vapour-density determinations or in ben-

* A measure of the association at the boiling-point may be obtained from Teouton's law, $\frac{MW}{T}$ = a constant, where W is the latent heat of vaporisation. For substances known to be normal in the liquid and gaseous states the value of the constant is in the neighbourhood of 21. For the esters and ketones a regular value of about 21 is obtained, but the acids and nitriles give exceedingly low values, indicating that the vapour at their boiling-points is strongly associated. The nitriles give fairly constant values, but still a little too low. Thus we find the order of complexity is nitroparaffin, fatty acid, nitrile, ketone, ester—the same order as indicated from the data for the boiling-points. The alcohols, on the other hand, give a high value, indicating association of the lighter molecules.

zene or phenol solution. In the case of the esters, which have the general formula

$$\begin{array}{c} \mathrm{OR'} \\ | \\ \mathrm{R \cdot C = O} \end{array}$$

the alkyl group R′ appears to hinder the association.

For the nitriles $\mathrm{R \cdot C \equiv N}$ there is the possibility of the formation of an immense number of complexes.

Now, seeing that all the compounds which behave in the manner described possess a double or treble linkage, it is reasonable to suppose that the nitroparaffins also are of this type. The following formulæ, out of the number that have been proposed for these compounds, show an ethylene linkage :—

$$(1.)\ \mathrm{R \cdot CH_2 \cdot N} \begin{array}{l} /\!\!/ \mathrm{O} \\ \backslash\!\!\backslash \mathrm{O} \end{array}$$

$$(2.)\ \begin{array}{c} \mathrm{OH} \\ | \\ \mathrm{R \cdot C = NOH} \end{array}$$

$$(3.)\ \begin{array}{c} \mathrm{O} \\ \| \\ \mathrm{R \cdot CH = N \cdot OH} \end{array}$$

The latter two, however, are the more probable, for several reasons. The hydroxyls explain the strong association in the liquid state (1·82 Traube); the association of the vapour and the phenomenon of the boiling-points of the series is due to the double linking. This structure also furnishes an explanation of the acid nature of these compounds; (2) makes these compounds exactly similar to the fatty acids, except that the group $=$NOH replaces the group $=$O.

(*b*.) The Boiling-points of the Alcohols: This series behaves in quite a different manner. The necessary data are shown in Table XIII.

TABLE XIII.

	Boiling-point.	Difference.
Methyl alcohol	66°	
Ethyl "	78	12
Propyl "	97	19
Butyl "	117	20
Amyl "	137	20
Hexyl "	157	20
Heptyl "	176	19
Octyl "	195·5	19·5
Nonyl "	213·5	18
Decyl "	231	17·5

The differences of the boiling-points reach a maximum early in the series, and then very slowly decrease. When the boiling-points are taken at reduced pressure the relative decrease is larger for the same alcohols. Now, at the lower temperature the liquid molecules are to a greater amount associated, and consequently this maximum is caused by the molecular complexity of the liquids. In all the cases mentioned above the results are different, but the explanation for those compounds is that the association of the vapour is the cause of the abnormal behaviour.

(3.) *When the Compounds are in the Solid State.*—(*a.*) Melting-points: Among the normal acids of the oxalic series the melting-points rise and fall, each term of the even series melting at a higher temperature than either of its two homologues of the odd series. If, however, the odd and even members are considered separately, a minimum melting-point is observed among the compounds containing an odd number of carbon atoms. This was pointed out by Massol,* and is shown in the following table:—

TABLE XIV.

C_3 Oxalic acid	... 212°	C_3 Malonic acid	... 132°
C_4 Succinic "	... 180	C_5 Glutaric "	... 97
C_6 Adipic "	... 148	C_7 Pimelic "	... 103
C_8 Suberic "	... 140	C_9 Azelaic "	... 117·5
C_{10} Sebacic "	... 127		

From these data it seems probable that the numbers for the melting-points in the even series will also fall to a minimum in the neighbourhood of the C_{14} acid.

The substituted malonic acids behave in a similar manner.

TABLE XV.

C_4 Methyl malonic acid	... 130°	
C_5 Ethyl "	... ...	111·5°
C_6 Propyl "	... 93·5	
C_7 Butyl "	... ...	98·5
C_8 Valeryl "	... 82	
C_{10} Heptyl "	... 97	

Here the minimum is reached when the substituent chain contains five carbon atoms; in the previous case the C_5 and in the fatty acids themselves the C_5 compound also shows the minimum melting-point.

In the case of the amides of the fatty acids the results are not so regular. Nevertheless, it is interesting to compare them.

* Bull. Soc. Chim., 1899, 578.

TABLE XVI.

C_2 Amide	... 82°	C_3 Amide	... 79°
C_4 "	... 115	C_5 "	... 115
C_6 "	... 100	C_7 "	... 95
C_8 "	... 110	C_9 "	... 92
C_{10} "	... 98	C_{11} "	... 81
C_{12} "	... 112	C_{13} "	... 98
C_{14} "	... 102	C_{15} "	... 108
C_{16} "	... 101		
C_{18} "	... 109		
C_{20} "	... 99		

The odd members behave regularly, showing a maximum at the C_5 amide, and then the values fall to a minimum. This is the only example of two changes of this nature that I have been able to find. The melting-points of the amides with an even number of carbon atoms show a more or less irregular nature.

The anilides also show a somewhat similar behaviour, but in this case it is the minimum which is reached in the C_5 compound.

(*b*.) Heats of Formation of the Oxalic Acids: The following data are due to Stohmann, Kleber, and Langbeim :—*

TABLE XVII.

Acid.	Heat of Formation.	Differences.	
Oxalic ...	... 196·8°		
		15·9	
Malonic ...	... 212·7		
			13·5
Succinic ...	... 226·2		
		2·6	
Glutaric ...	... 228·8		
			11·3
Adipic ...	... 240·1		
		2·3	
Pimelic ...	... 242·4		
			7·0
Suberic ...	... 249·4		
		7·3	
Azelaic ...	... 256·7		
			7·5
Sebacic ...	... 264·2		

The values for the heat of formation increase with the molecular weight just as the boiling-points do. But on taking differences and separating the values thus obtained alternately into two sections we find that both series reach a minimum in the neighbourhood of pimelic acid. This is the only instance in which the two minima occur in neighbouring members; usually there is a wide difference.

GENERAL CONCLUSIONS.

As regards the position of the maximum or minimum in the series, we must first consider the results in division A. In only one case does the change occur well up the series;

* J. pr. Chem., 40, 202.

this is for the fatty acids in phenol, the association of which compounds reaches a maximum at about the twelfth member.

When, as in B, the data are divided into two sets the point under consideration is reached early in the one series, and generally much later in the other. Almost always the position for the first of the changes occurs in the neighbourhood of the compound with a chain containing five carbon atoms. This is in accordance with the stereo-chemical conclusion that a chain of this length returns on itself.

In all the examples enumerated under B, except that of the differences of the boiling-points of the alcohols, the data for the series alternately increase and decrease as the molecular weight increases. Further, in two out of the four examples in A a probable connection is shown. From this we arrive at the general result.

"*In all cases where we find a maximum or minimum in the physical properties of a series, either by taking each member in turn or by taking alternate members, the data for that series, either for the same or a closely related property, is found to rise and fall alternately.*"

Again, whenever the series dealt with referred to the liquid or gaseous state evidence of molecular association has been forthcoming. Consequently we obtain the second conclusion: "*A maximum or minimum in a series is due to the molecular complexity of one or more members of that series.*"

Art. LVIII.—*A Contribution to the Chemistry of Colophony.*

By T. H. Easterfield and G. Bagley.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

Colophony, or common rosin, is one of the cheapest of all organic preparations. It is the residue which remains in the still when crude turpentine is being worked into oil or spirit.

Colophony has been investigated by numerous chemists; nevertheless, many points in the chemistry of the substance remain to be cleared up. It is, moreover, unfortunate that several investigators have published statements which have not been confirmed by subsequent workers, so that a mere perusal of the literature is not sufficient to separate the facts from the fiction.

The following facts are in general accepted amongst chemists:—

(1.) Colophony consists principally of organic acids, of which one, abietic acid, is in preponderating proportion. The use of rosin in soap-making depends upon its acidic nature.

(2.) Rosin, when distilled at ordinary pressures, yields a very composite mixture of substances, consisting chiefly of hydrocarbons, the more volatile portions of which are known as "rosin-spirit," the less volatile as "rosin-oil." The oil is largely used in the preparation of lubricants for heavy machinery. Rosin-oil consists very largely, according to Deville, of a hydrocarbon the percentage composition of which approximates to that of turpentine, but the molecular weight of which is much greater. It is generally regarded as a diterpene.

(3.) When distilled under diminished pressure, rosin is said to yield an anhydride of an acid isomeric with abietic or sylvic acid, together with a hydrocarbon, probably the "colophene" of Deville. This statement is due to Bischoff and Nastvogel. The authors greatly regret that their work has led them to conclusions of a totally different nature.

Put shortly, the results of the present investigation may be thus stated:—

(1.) When colophony is fractionally distilled under diminished pressure a small quantity of turpentine and other hydrocarbons distil first. The greater part of the rosin then comes over in an unchanged state, between 260–285° C., at 15 mm. pressure. This is nearly pure abietic acid. Lastly, there is a small quantity of pitch, which has so far defied all attempts at investigation. The distillation of colophony under diminished pressure is an excellent method of obtaining crude abietic acid; for the middle portion of the distillate, when twice crystallized from alcohol, yields practically pure abietic acid melting at 163–165° C.

(2.) If the distillation be conducted slowly, the early portion of the distillate increases in quantity, whilst the second portion diminishes. The pitch increases at the same time. Careful examination of these facts has shown the authors that this change in the yield, with the altered conditions, is due to the fact that the hydrocarbon is produced from abietic acid according to the equation—

$$C_{19}H_{28}O_2 = C_{18}H_{28} + CO_2.$$

This hydrocarbon, though evidently identical with that found by Deville in 1841 amongst the products of the distillation of colophony,* is not, as has hitherto been supposed, a diterpene, but appears to be a member of a special series. The name abietene is proposed for this compound. The authors have

* See Liebig's "Annalen," 37, 193.

little doubt that the so-called diterpene obtained by Liebermann* and by Haller† by the action of hydriodic acid on abietic acid is dihydro-abietene.

The results obtained by the vacuum distillation led to the belief that similar results would be obtained by the distillation of colophony with superheated steam. A patent for the purification of colophony by this process was taken out by Hunt and Pochin in 1858; but no account has been published of the chemistry of the process, if, indeed, it has ever been the subject of investigation.

Experiments on the steam distillation of rosin were therefore carried out at Kaiwarra by the kind permission of the directors of the New Zealand Candle Company. The results were completely as anticipated, water-white rosin, heavy hydrocarbon, and a small quantity of pitch being practically the only substances produced by the process.

Experimental.

Preliminary Experiment.

105 grms. of rosin (N quality) was distilled under diminished pressure (18 mm. approximately). The course of distillation was as follows: Up to 270° C., 23 grms.; 270–285° C., 67 grms.; pitch, 12 grms.; loss, 3 grms.

The portion distilling at 270–285° was refractionated. About 70 per cent. of it passed over between 262–268° C. as a light-yellow oil, which when rapidly cooled set to a hard transparent resin; but which when cooled slowly became opaque, owing to the formation of crystals, which gradually increased in quantity until the whole mass was crystalline.

This substance was analysed, and gave numbers agreeing closely for those required for abietic acid, but not for those required by the "isosylvic anhydride" of Bischoff and Nastvogel.

Calculated for Abietic Acid—$C_{19}H_{28}O_2$.	Found.		Calculated for Isosylvic Anhydride—$C_{40}H_{58}O_3$.
C = 79·16	78·88	78·86	81·9
H = 9·72	9·77	9·80	9·9

Confirmatory Experiment.

As it appeared possible that the difference between these results and those recorded by Bischoff and Nastvogel might be due to the fact that their distillations were carried out under higher pressure, and that their distillates were more frequently fractionated, a fresh set of experiments was made.

* Berichte, 17, 18841.
† Berichte, 18, 2165.

(*a*.) Four hundred grams of colophony was distilled with a rod and disc fractionation column at a pressure of 31 mm. The portion distilling between 270–290 weighed 222 grms. This was redistilled five times, at pressures varying from 27–35 mm. The second, fourth, fifth, and sixth distillates were analysed, but the results only confirm the conclusion arrived at in the preliminary experiment. The numbers obtained were as follows:—

Calculated for Isosylvic Anhyd.	Calculated for Abietic Acid.	Found 2nd Distillate.	4th Distillate.	5th Distillate.	6th Distillate.
C = 81·9	C = 79·16	78·8	78·7	78·8	78·9
H = 9·9	H = 9·72	9·6	9·5	9·8	9·7

As the composition of the distillate had not changed during six distillations, it was evidently useless to continue the fractionation further.

According to Bischoff and Nastvogel, the "anhydride" dissolves in alkali, and when reprecipitated by dilute acetic acid yields isosylvic acid melting at 61–63° C., and isomeric with sylvic or abietic acid. The sixth distillate was accordingly dissolved in potash, shaken out with ether to remove any oily impurities, and reprecipitated according to Bischoff's and Nastvogel's directions. Two preparations melted respectively at 65–73 and 67–80. The latter was recrystallized from 80 per cent. alcohol, from which it separated in crystals, having the characteristic crystalline form and melting-point (160–165) of abietic acid. The evidence is thus complete for the non-existence of isosylvic acid and its anhydride.

The low melting-point of the precipitated acid as compared with the crystalline acid is easily understood. The precipitated acid is amorphous, and has no definite melting-point. When once melted and kept a few degrees above its melting-point it crystallizes. The crystals must then be raised to a higher temperature before they melt. A number of analogous cases might be quoted.

Abietene.

In the series of fractionations above described a small quantity of low boiling-point material was invariably observed, even in the last distillation. This indicated that even under the most favourable circumstances a slow decomposition was taking place, a conclusion that was supported by the fact that even when the pressure was reduced to 11 mm. the liquid in the distilling-flask did not bump. The most evident reaction which might explain this phenomenon is that abietic acid is losing carbon-dioxide and yielding the corresponding hydrocarbon, the name of which should be "abietene," from analogy in the case of benzoic acid and benzene.

To test this conclusion 36 grms. of crystallized abietic acid was heated in a four-bulb Ladenburg flask at 30 mm. pressure, the temperature in the uppermost bulb being maintained at 210–220° C. Under these circumstances an almost colourless distillate was obtained, and this consisted of an oil which did not solidify on cooling. After five hours' heating the contents of the distilling-flask had become so pitchy that the heating was discontinued. The distillate amounted to 44 per cent. of the acid taken, and consisted of an almost colourless faintly florescent viscous oil, which still contained some abietic acid. The oil was dissolved in toluene, freed from acids by washing with caustic soda, and dried, first over calcium-chloride and afterwards by sodium. Finally, the toluene was removed by distillation, and the residue distilled at 19 mm. pressure. Practically the whole came over between 300–315° C. The product was redistilled over sodium at 82 mm. pressure, when the greater portion distilled at 247–250° C. This was analysed, with the following results:—

Calculated for $C_{18}H_{28}$	Found.
C=88·5	88·3
H=11·5	11·7

The molecular weight was kindly determined by Mr. P. W. Robertson in phenol solution.

Found.	Calculated for $C_{18}H_{28}$
244	244
249	

taking 72 as the depression constant of phenol. (Eykman.)

It is worthy of note that, though a second receiver was attached and kept in a freezing mixture during the whole distillation, no volatile products, except a few drops of water slightly discoloured by oil, could be detected. The same hydrocarbon is easily obtained by the slow distillation of common colophony.

In order to prepare a quantity of the hydrocarbon, a kilogram of common rosin was distilled from a cast-iron retort, provided by means of a stuffing-box, with a rod and disc fractionating column. With a little care it was easy to maintain the still-head at 215–230° C., the pressure being kept at 15–35 mm. 100 grms. of the oily distillate was dissolved in 300 c.c. of light petroleum, thoroughly agitated with 400 c.c. of 1 per cent. soda-solution, and sufficient alcohol to prevent the formation of a permanent emulsion. The soap-solution was shaken out with a second quantity of petroleum. The hydrocarbon was dried by calcium-chloride, the light petroleum removed by distillation, and the heavy oil fractionated in vacuo. The following fractions were obtained:—

Boiling-point.	Pressure.	Weight of Distillate.
241–250°	80–85 mm.	8·3 per cent.
250–253	81 mm.	63·7 „
256–272	81 mm.	6·9 „

Residue = 3·9 per cent.
Acid recovered from washings = 14 per cent.
Loss = 3·2 per cent.

The fraction boiling at 250–253 was redistilled several times over sodium. When analysed different samples gave numbers agreeing with those already given for the compound prepared from crystallized abietic acid. Different specimens gave:—

Calculated for $C_{18}H_{28}$.	I.	II.	III.	
C = 88·5	88·3	88·2	88·5	88·7
H = 11·5	11·1	10·9	11·0	11·3

Further evidence of the identity of the two substances is shown by the similarity of their physical constants.

	Hydrocarbon from Abietic Acid.	Hydrocarbon from Crude Rosin.
Specific gravity	0·9728 at 19° C.	0·9727 at 18° C
Refractive index	1·537 „ 20° C.	1·538 „ 12° C.
Boiling-point	247–250 „ 82 mm.	199–200 „ 13 mm. 253–255 „ 82–85 mm. 340–345 „ 760 mm.

The hydrocarbon from crude rosin is optically active. It gave the value $[\alpha]_d = 92·9$.

In 1884 Liebermann* obtained a hydrocarbon approximating in composition to that of a terpene by heating abietic acid with hydriodic acid and phosphorus at a temperature of 240° C. It appeared of great interest to learn whether the formation of this hydrocarbon was due to the reducing-action of hydriodic acid, or, as it appeared more probable, to the splitting-off of carbon-dioxide. Experiment showed that the latter hypothesis was the corrct one.

Five grams of abietic acid was heated in a sealed tube with 20 c.c. of fuming hydriodic acid for six hours at a temperature of 210–230° C. The gas which collected in the tube consisted largely of carbon-dioxide, and the abietic acid was transformed into a hydrocarbon. This was purified in the usual way. It was then found to boil for the most part at 245–255° C. at 84 mm. pressure. The quantity of material was insufficient for a complete purification; but the analytical results and physical constants leave little doubt that the product of the action of hydriodic acid is identical with that formed by the distillation under diminished pressure. The analyses gave:—

* Berichte, 17, 1885.

Calculated for $C_{18}H_{28}$.	Found.
$C = 88{\cdot}5$	88·2
$H = 11{\cdot}5$	10·9

Specific gravity = 0·962.
Refractive index = 1·5317.
Boiling-point = 245–255.

Liebermann's hydrocarbon boiled at 330°–340° (at ordinary pressure), and contained 1 per cent. more hydrogen than the compound here described—it was probably dihydroabietene produced by the reducing-action of the hydriodic acid and phosphorus at the higher temperature.

Distillation of Rosin with Superheated Steam.

Preliminary Report.

Sixteen hundred and fifty-five pounds weight of rosin (N quality) was placed in a 3-ton stearine still, melted, and superheated steam blown through the mass. When the temperature of the still-head had risen to 268° C. an oily distillate began to come over. The temperature gradually rose to 299° C. The distillate was almost colourless, and set upon cooling to an almost colourless resin. At 305° C. the distillate was water-white. At 310° C. it began to darken, and came over more slowly. The temperature was accordingly raised, until at 332° C. the distillation was stopped, and the pitch blown out by the pitch-pipe. During the whole distillation the third, fourth, and fifth coils of the still yielded a viscous distillate which did not set on cooling. The quantities obtained were as follows:—

	Lb.	Per Cent.
Hard distillate	1,052	63·6
Soft "	424	25·6
Pitch and loss	179	10·8

The pitch being very hard a great portion of it refused to leave the still, a fact that made itself abundantly evident the next time the still was used.

Hitherto only the light-coloured portion of the distillate has been analysed. It contained C = 79·7; H = 9·7; and thus consisted principally of abietic acid. The other portions of the distillate are under examination.

In conclusion, the authors desire to express their indebtedness to Messrs. Newton and Son and to the directors and secretary of the New Zealand Candle Company for the assistance they have given in the carrying-out of the above investigation.

Art. LIX.—*On a Supposed Magnetic Sense of Direction in Bees.*

By F. W. Hilgendorf, M.A., B.Sc.

[*Read before the Philosophical Institute of Canterbury, 26th November, 1902.*]

At the close of Captain Hutton's address on "Our Migratory Birds," delivered at the annual meeting of this society on the 3rd April, 1901, Dr. Farr suggested that birds might be possessed of a magnetic sense by which they were guided in their migrations, and he also suggested that it was by some such sense that bees found their way back to their hives.

The suggestions passed from my memory until I read Mr. Hudson's presidential address on "The Senses of Insects," delivered before the Wellington Philosophical Society in the same year.* There Mr. Hudson detailed Romanes's experiments on the sense of direction, and repeated the conclusion to which Romanes and Lord Avebury independently came—viz., that ants and bees do not find their way home by any special sense of direction, but by a knowledge of the district in which they are working. During the same week I was working with my bees, and in the busy time of the day, when many of the bees were out foraging, I had occasion to move a hive 3 ft. to one side. In a few minutes a number of bees had alighted on the former site of the hive, and crawled about there, or rose and circled round the spot, without making any attempt to enter the hive standing only a foot or two away. All those that were out at work when the hive was moved came back to the old site, and stayed there until night fell, when they perished of cold; and this experience is not exceptional, but is familiar to all bee-keepers.

On the face of it, it does not seem that the bees find their way to their hive by sight, or they should see their hive and fly to it, instead of flying to a place where there is no hive to be seen. It would rather look as if they felt by some unknown sense the direction in which they set out, and

* Trans. N.Z. Inst., vol. xxxiv., p. 18.

blindly came back to the same place. On the other hand, if during the night a hive is moved to a distance much greater than that I have mentioned—say, 50 yards—the bees in the morning will start work quite freely; none will go back to the old site, but all will find their way back to their new position. This also looks as if these insects had a sense of direction, and came back to the point from which they set out on any particular journey.

On another occasion I had reason to bring a hive into my laboratory to have them under close observation. There are four similar windows close together, but of these the bottom sash of only one opens. I opened that for the bees to come in and out by, left the other three closed, and put the hive with its door facing the open window. Many of the bees on leaving the hive struck the closed windows, stayed on the glass for a time, and I never saw one in such circumstances leave the glass and drop down to the hive, 2 ft. away, or go round to the open window, 12 in. away. They all—to the number of hundreds—stayed on the glass till they fell dead or dying on to the sill. After the first day I blocked the other windows, and left them so for a fortnight, by the end of which time the bees were thoroughly used to their new quarters, and were working and breeding vigorously. It is fair to presume that by now practically all the bees in the hive were familiar with the open window, and the way in and out. I raised the blinds, and again all those that struck the glass stayed there and died, though they surely knew of the open window just beside them. In this case, too, it hardly seemed that the bees could see for any distance sufficient to warrant the supposition that they found their way about by sight, or they surely would have flown back to their hives.

Such are the facts and considerations that induced me to undertake the experiments I am about to record. At the same time, I may state that I did not believe in a sense of direction. On one occasion I moved a hive 50 yards during the night, and shut it up till I was at liberty to deal with it in the morning. I then took out fifty bees and marked them, carried them 200 yards across the garden and liberated them. They all went back to the place where the hive had been on the previous night. This in itself disproved the idea of a sense of direction, and proved that the bees found their way by sight; and numerous other experiments, and chiefly those by Romanes, clearly prove the same facts. The apparent want of sight argued in my other experiences is easily explained by the consideration that the actions of bees are prompted not by reason, but by instinct, which I think in no other case is so well characterized by its true epithet of "blind instinct."

However, notwithstanding my conviction that there was no sense of direction in bees, Dr. Farr's theory seemed well worth testing, and I tested it by the following experiments:—

1. I saw that in some cases it would be necessary to work with drones instead of with workers, owing to the difficulty of handling the latter. So I first proved that drones would come home rapidly and unfailingly from any distance that I was likely to experiment from. I took ten drones and rolled them in flour, and carried them away from the hive to the distance of one-third of a mile. All returned within five minutes.

2. I tried the same experiment with workers, but it failed entirely. The workers settled on the grass or a tree and cleaned themselves of the flour before they came home; many also, since they were out, stayed out for their load of honey or pollen, and so by the time of their return were unrecognisable.

After various other attempts to secure an easy way of watching the bees come home I was forced to adopt the arrangement that Romanes made in his experiments and have the experimental hive indoors. My first attempt to test the magnetic suggestion was to put the bees in a box of soft iron, of sufficient thickness of wall and of sufficiently contracted content to screen off all the earth's magnetism from the bees inside the box. This proved exceedingly inconvenient, and I then determined to use a powerful bar magnet, which would so distort the lines of force due to the earth's magnetism as to render them inappreciable to the bees carried close to the magnet.

(*a.*) I took twenty-seven bees from the hive and carried them 100 yards away round to the back of the building. Nine bees had returned within two minutes, twenty-four within fifteen minutes, twenty-six within forty-five minutes; and one did not return, and was probably injured during capture or transit. Those that came back between two and fifteen minutes from liberation were usually laden with pollen, having seized the opportunity for commencing work.

(*b.*) I took twenty-six bees to the same place, carrying them on their outward journey in a test-tube lying on a bar magnet with the north pole held pointing south. Twenty-two bees had returned within fifteen minutes, and the twenty-six within thirty minutes.

(*c.*) I took twenty-eight bees to the same place in the same manner, but this time the north pole, on which they were held, was rotated horizontally, so as to point to all points of the compass many times during the journey. Twenty-one bees had returned within three minutes, and the twenty-eight within fifteen minutes.

(*d*.) I took eighteen bees to the same place in the same manner, but held them between the north and south poles of a strong horse-shoe magnet, which I rotated horizontally and vertically during the journey. Four bees had returned within two minutes, thirteen within five minutes, and the eighteen within fifteen minutes.

The bees were coming home rather better in the latter experiments: this was due probably to the increasing temperature of the day.

These experiments give a sufficiently clear proof of at least one thing: viz., that if the bees do find their way home by a magnetic sense they do not do so in the way that we should. They do not take their bearings in their outward journey and then reduce their traverse and set home along the resultant line. If all the lines of force due to the earth's magnetism are exactly the same, the experiments prove that the bees do not find their way home by magnetic sense at all. It is exactly as if a man lived in a uniform plain crossed by a great number of parallel and exactly similar tracks. When he left his home he would say, "I have crossed thirteen tracks to the north, thirty-two to the east," and so on, and then would be able to strike straight back home; but if he were led away from home blindfolded, so that he could not count the tracks, and then given his sight, he would not be able to tell in which direction his home lay. If the tracks were similar, if he were led away blindfold, and if he found his way back, we could say he did not find his way home by sight. This is exactly what I did with the bees. I blindfolded their magnetic sense, and they found their way home; so that I can say they did not do so by magnetic sense. But let us suppose all the tracks across the uniform plain were not similar. Suppose they increased in breadth in regular succession, one being 1 in. wide, the next 2 in., the next 3 in., &c., and the cross-tracks the same. Then a man would know "My house is at the intersection of the track 3 ft. wide and the track 9 in. wide." Now lead him away from home blindfold and then set him free: no matter where he is he will return to his home. Let us apply this case to the bees. Suppose the lines of force due to the earth's magnetism are not all exactly similar, but increase in strength in a particular direction. Then the bee, no matter where it was taken, would, when liberated, know what line of force it was on, would know in what direction lay the line of force on which its hive was, and would fly direct for that. In this supposititious case my former experiment was completely inconclusive, because I blindfolded the magnetic sense of the bees and then gave them their sight in a locality with which they were perfectly acquainted. It was to meet

this possible view of the case that I made the following experiments.

3. I here wished to disturb or annul the magnetic field in which the bees usually lived, both on their outward and homeward journey: to follow up my original illustration, to obliterate all the tracks across the plain, and make only one broad and distinct track, that would go wherever the man went, and disappear immediately behind him. To do this I attached a small powerfully magnetized needle to the back of the thorax of the bee, carried him 100 yards away from his hive, and liberated him. The attached magnet was sufficiently strong to hold a small suspended magnet at right angles to the lines of force of the earth's magnetism. The weight of the attached magnet and the adhesive used was 40 milligrammes; the average weight of the bees used was 120 milligrammes; so that the load was one-third of the bee's own weight. I used drone bees in this experiment, as they were stronger, to carry the magnet, and as workers would have injured themselves by using their stings during the fixing of the magnet. I fastened the magnets to the bees in all directions—*i.e.*, with the north pole pointing over their head, with the south pole pointing over their head, and with the poles pointing to left and right of the bees. About one-third of the bees were unable to carry their burden, and fell into the grass when liberated. These were not counted, only those that flew into the air from my hand being included in the following numbers: Bees liberated, 12; returned home, 8. Of the four that were lost two were evidently weak on starting, and the number that returned was large considering the disadvantages they were flying under.

This experiment answers the objection I supposed, and makes it still more improbable that the bees find their way home by magnetic sense, for this sense was in effect blindfolded, both on their outward and return journeys, and still they came home. The only other objection I can conceive is this: Suppose the attached magnet were not strong enough to completely obliterate the lines of force of the earth's magnetic field, but only to distort them, then, since in the last experiment the lines were distorted consistently equally on the outward and homeward journey, the distortion might not count for anything. A little consideration of the two former experiments will prove that this objection is invalid, but with a view to refuting it experimentally I made my last test.

4. In this case I took the bees away from home in their natural magnetic field. At 100 yards away I fastened to them the magnet in all the three positions before mentioned, and then liberated them: Bees liberated, 5; returned home, 3. Thus in the third case also it appeared that the bees' power

of finding their way home was not impaired by the disturbing of their magnetic field.

These experiments seem to me to prove clearly enough that bees do not find their way back to their homes by a magnetic sense of direction. As to how they do find their way home, I agree that they have an intimate sight acquaintance with the locality in which they are working, and that they fly from one large known object to another. I have never seen the muscular sense alluded to as a source of the information by which the bee finds its way home. Yet this sense appears to me very important as assisting the sense of sight; or it might even be that it is of equal importance with sight, by which it is checked and corrected. When a bee alights on the spot from which its home has been moved, on missing its home it flies back to some large known object, from which it seems to take its bearings, and then again flies straight to the old position of the hive. I had a hive on the east side of an open window, and facing it, so that a bee had to fly west to get out of the window. I turned the hive round to the west side of the window, but still facing it. The bees leaving the hive still tried to fly westward, and struck themselves against the front of the hive, and lost the opening of the window, just as a man will habitually turn to the right or left when he leaves his house-door. As for the bees that were coming home from work, when they got to the window they were hopelessly lost, and hovered about the old position, although the new position of the lighting-board was not 18 in. from the old. In their circling flight they often struck the hive or rested on the lighting-board, but that was of no assistance to them, as they immediately flew off again to look or feel for their home. When the hive was returned to its original position they rushed in at the opening with a contented hum. These facts seem to indicate that the bees are not dependent on the sense of smell for finding the hive, and that their sense of sight is not sufficient to guide them in new situations, and that they largely depend on the muscular sense.

To settle these points is, however, beyond my present purpose, which was merely to accurately compute the value of the suggestion that bees found their way home by a magnetic sense of direction.

If any further proof were needed that the bees do find their way home by sight the following experiments would furnish it. I took a hive from my laboratory after having it closed all night, and put it 300 yards away in the garden. I opened it at 11 o'clock on a fine sunny day. The bees came out, and, apparently tempted by the fine weather, set off working without taking sufficient notice of their surround-

ings, for of the whole colony I estimate that one-twentieth came back to the laboratory—the old position of the hive. On the other hand, I moved a hive similarly but opened it after dark, and then next day no bees came back to the old position of the hive, because, I suppose, when the first few came out at daylight they did not fly off to work at once, but took short flights round the hive and so recognised their new location.

ART. LX.—*List of Papers on the Geology of New Zealand.*

By A. HAMILTON.

[*Read before the Wellington Philosophical Society, 18th March, 1903.*]

IN this list of papers on subjects relating to the geology of New Zealand I have endeavoured to bring together in a convenient form for reference the titles of the various reports, papers, essays, and stray notes not only directly and purely geological, but those which contain information on subjects such as mining and mineralogy, petrography and palæontology, which must of necessity be considered by a practical geologist.

The chief store of information is, of course, the series of reports by Sir James Hector, Director of the Geological Survey of New Zealand, from 1862 to date; and it is hoped that, failing an elaborate and costly index to these reports, such as that published for the reports of the Geological Survey of Canada, the present list, arranged under the names of the various officers of the Survey and other writers, will have some value to those in search of information on any particular district or subject. The other publications which have been searched are the "Transactions of the New Zealand Institute," so far as published papers are concerned, extracts having been made from the Proceedings in only a few special cases, the "Quarterly Journal of the Geological Society" of London, the "Geologist," and sundry other publications in various parts of the world.

In some subjects, such as earthquakes, gold and coal mining, ironsand-working, many additions could be made to the list by those specially interested. I am in hope, however, that some one with leisure will not only greatly extend this list, but will rearrange the entries under headings similar to those in the annual "Geological Record," thereby making reference more easy.

The numerous palæontological papers treating of the extinct birds of New Zealand have been already given in a list published in vol. xxvi. of the "Transactions of the New Zealand Institute," and vol. xxvii., p. 229, 1894.

[NOTE.—In the following list "Trans." means the "Transactions of the New Zealand Institute."]

Author.	Title.	Name of Publication.
Andrews, E. W. ..	Pebbles and Drifting Sand ..	Trans. xxvi. 397
Allen, F. B. ..	Minerals in the Gold-bearing Reefs of the Thames	N.Z. Mines Record, ii. 20.
	Notes on the Valuation of Gold Specimens	N.Z. Mines Record, iv. 147.
	Tellurium in the Ores of the Hauraki Goldfields	Trans. Aust. Inst. of Mining Eng. 1901; N.Z. Mines Record, iv. 468.
Baker, J. H. ..	On Mount Cook Glacier Motion	Aust. Assoc. Adv. Sci. iii. 153.
Barff, Ed. ..	Notes on the Recent Changes in the Apex of Mount Cook	Trans. vi. 379.
Beal, L. O. ..	On the Deposition of the Alluvial Deposits in the Otago Goldfields	" iii. 270.
	The Alluvial Deposits of Otago	" xxi. 332.
Beetham, G. ..	Account of Two Journeys to the Summit of Ruapehu (abstract)	" vii. 423.
Binns, G. J. ..	Report on Hæmatite at Parapara	Rep. N.Z. Geol. Surv. 59, 1878–79.
	On a Striated Rock-surface from Boatman's, near Reefton	Trans. xxi. 335.
Blackett ..	Report on the Buller and Grey Coalfields	Nelson Gazette, May 12, xi. No. 14, 1863.
Blair, W. N. ..	Building Materials of Otago ..	Dunedin, 1879.
Blanchard, Emile	Proofs of the Subsidence of a Southern Continent during Recent Geological Epochs. Republished (abstract) from "Comptes Rendus"	N.Z. Jrnl. Sci. i. 251.
Boehm, Georg ..	Reisenotizen aus Neu-Seeland	Abd. a.d. Zeitschr. d. Deutsch. Geol. Gesellenschaft, 1900.
Bonney, T. G. ..	Review of Harper, A. E., Pioneer Work in the Alps of New Zealand. London, 1896	Nature, lv. 458.
	Review of Fitzgerald, E. A., Climbs in the New Zealand Alps. London, 1896	" lv.
	Review of Green, W. S., The High Alps of New Zealand, or a Trip to the Glaciers of the Antipodes. London, 1883	" xxix. 281.
Bramhall, H. ..	The Mineral Resources of New Zealand	Trans. Liverpool Geol. Assoc. 1883.
Buchanan, J. ..	On the Wanganui Beds ..	Trans. ii. 163.
	On the Belemnite Beds at Amuri Bluff	Rep. N.Z. Geol. Surv. 1867.

Author.	Title.	Name of Publication.
Bunbury, C. ..	The Geysers of New Zealand ..	Fraser's Mag. 761, 1879; Living Age, 812, 1879.
Burnett.. ..	Report on that Part of the Grey Coalfields situated at Mokihinui; also on Part of the Grey Coalfield North of the Buller River	Nelson Gazette, April 20, xi. No. 8, 1863.
	An Account of the Wangapeka and Batten Goldfields	Nelson Gazette, June 8, xi. No. 16, 1863.
	Trials of West Coast Coals ..	Nelson Gazette, July 6, xiv. No. 16, 1866.
	Report of the Grey Coalfield North of the Buller River	Nelson Gazette, Nov. 3, x. No. 21, 1862.
Cadell, H. M. ..	Gold-mining in Hauraki District, New Zealand	Trans. Fed. Inst. Mining Eng. 1, 1895.
Campbell, W. D...	Report on the Kanieri and Grey River Coal Districts	Rep. N.Z. Geol. Surv. 31, 1876–77.
	On Crystalline Rocks ..	Trans. xiv. 450.
	Notes on a Pseudomorphous Form of Gold	„ xiv. 457.
Carpenter, W. Lant	On the Hot Lake District and the Glacier Scenery and Fjords of New Zealand (abstract)	Rep. Brit. Assoc. 742, 1881.
	On the Siliceous and other Hot Springs in the Volcanic District of the North Island of New Zealand	Rep. Brit. Assoc. 742, 1881; Nature, xxiv. Sept. 15.
Carruthers, J. ..	Volcanic Action regarded as due to the Retardation of the Earth's Rotation	Trans. viii. 351.
	On the Formation of Detached Shingle Beaches	„ x. 475.
Chapman, H. S...	Earthquakes in New Zealand ..	Westminster Rev. li. 390.
Collie, W. ..	Remarks on Volcanoes and Geysers in New Zealand	Trans. xii. 418.
Connelly, T. F. ..	Exploration of Tongariro ..	Nature, Feb. 28, lxxviii. 346.
Cox, S. Herbert ..	Report on Antimony-mine, Queen Charlotte Sound	Rep. N.Z. Geol. Surv. 2, 1874–76.
	Report on Coal at Wairarapa ..	Rep. N.Z. Geol. Surv. 1, 1874–76.
	Report on Nelson District ..	Rep. N.Z Geol. Surv. 7, 1874–76.
	Report on Raglan and Waikato Districts	Rep. N.Z. Geol. Surv. 9, 1874–76.
	Report on Survey of Buller Coalfield	Rep. N.Z. Geol. Surv. 17, 1874–76.
	Report on the Geology of Resolution Island, Dusky Sound	Rep. N.Z. Geol. Surv. 30, 1874–76.
	Report on Argentiferous Lode at Collingwood (Richmond Hill Silver-mine)	Rep. N.Z. Geol. Surv. 59, 1874–76.
	Report on the Westland District	Rep. N.Z. Geol. Surv. 63, 1874–76.
	Report on the Country between Poverty Bay and Napier	Rep. N.Z. Geol. Surv. 96, 1874–76.

Author.	Title.	Name of Publication.
Cox, S. Herbert ..	Report on Coal-measures at Jackson's Bay	Rep. N.Z. Geol. Surv. 94, 1874–76.
	Report of Survey of Buller Coal-field	Rep. N.Z. Geol. Surv. 106, 1874–76.
	Notes on the Valley Systems on the Western Flanks of Mount Cook	Trans. ix. 577.
	Report on the Geology of the Mount Somers District	Rep. N.Z. Geol. Surv. 1, 1876–77.
	Report on Waikato District ..	Rep. N.Z. Geol. Surv. 11, 1876–77.
	Report on the Geology of the Whangarei District	Rep. N.Z. Geol. Surv. 95, 1876–77.
	Report on the Country between Opotiki and the East Cape	Rep. N.Z. Geol. Surv. 107, 1876-77.
	Report on Richmond Hill Silver-mine	Rep. N.Z. Geol. Surv. 155, 1876–77.
	Report on the Tuapeka Cements	Rep. N.Z. Geol. Surv. 42, 1878–79.
	Report on the Wakatipu and Greenstone Districts	Rep. N.Z. Geol. Surv. 53, 1878–79.
	Report on the D'Urville Island Copper-mine	Rep. N.Z. Geol. Surv. 55, 1878–79.
	Report on certain Mines in the Nelson and Collingwood Districts and the Geology of the Riwaka Range	Rep. N.Z. Geol. Surv. 1, 1879–80.
	Geology of the Rodney and Marsden Counties	Rep. N.Z. Geol. Surv. 13, 1879–80.
	Auriferous Reefs in the Rimutaka Ranges (Brandon's Reef)	Rep. N.Z. Geol. Surv. 11, 1879–80.
	Notes on the Mineralogy of New Zealand	Trans. xiv. 418–450.
	Chrome-deposits of Nelson ..	Rep. N.Z. Geol. Surv. 3, 1881.
	Supplementary Report ..	Rep. N.Z. Geol. Surv. 8, 1881.
	Aniseed Valley Company's Copper-mine	Rep. N.Z. Geol. Surv. 10, 1881.
	Supplementary Report ..	Rep. N.Z. Geol. Surv. 12, 1881.
	District between the Aorere and Takaka Valleys, Collingwood	Rep. N.Z. Geol. Surv. 42, 1881.
	Wallsend Colliery, Collingwood	Rep N.Z. Geol. Surv. 16, 1881.
	North Island District, including Thames, Coromandel, Island of Kawau, and Drury Coal-fields	Rep. N.Z. Geol. Surv. 17, 1881.
	Richmond Hill Silver-mine ..	Rep. N.Z. Geol. Surv. 13, 1881.
	On certain Points connected with the Geology of the Auckland District	Rep. N.Z. Geol. Surv. 92, 1881.
	Notes on the Mineralogy of New Zealand	Trans. xv. 409.

Author.	Title.	Name of Publication.
Cox, S. Herbert ..	On a New Mineral belonging to the Serpentine Group (Hectorite)	Trans. xv. 409.
	The District around Norsewood	Rep. N.Z. Geol. Surv. 1, 1882.
	Goldfields of Cape Colville Peninsula	Rep. N.Z. Geol. Surv. 4, 1882.
	On certain Alluvial Gold-workings in Westland	Rep. N.Z. Geol. Surv. 51, 1882.
	On Shag Valley	Rep. N.Z. Geol. Surv. 55, 1882.
	Brockley Coal-mine and Surrounding District	Rep. N.Z. Geol. Surv. 57, 1882.
	On the District between Collingwood and Big River	Rep. N.Z. Geol. Surv. 62, 1882.
	On the History of the Aorere River, Collingwood, since Miocene Times	Trans. xvi. 548.
	On the Occurrence of some New Minerals in New Zealand	" xvi. 448.
	Quartz Reefs at Gollan's Valley	Rep. N.Z. Geol. Surv. 11, 1883–84.
	Maruia and Upper Buller Districts	Rep. N.Z. Geol. Surv. 1, 1883–84.
	Coal Prospects at Whau ..	Rep. N.Z. Geol. Surv. 10, 1883–84.
	Mount Somers and Malvern Hills District	Rep. N.Z. Geol. Surv. 22, 1883–84.
	Terawhiti, Duke of Wellington Mine	Rep. N.Z. Geol. Surv. 66, 1883–84.
	Terawhiti, Success Mining Claim	Rep. N.Z. Geol. Surv. 82, 1883–84.
	Motueka Water-supply ..	Rep. N.Z. Geol. Surv. 87, 1883–84.
	Aorere River	Rep. N.Z. Geol. Surv. 67, 1883–84.
	Springfield Colliery	Rep. N.Z. Geol. Surv. 19, 1883–84.
	Nelson Champion Copper-mine	Rep. N.Z. Geol. Surv. 84, 1883–84.
	Westland Sluicing Claims ..	Rep. N.Z. Geol Surv. 88, 1883–84.
	Mount Somers Porphyries ..	Rep. N.Z. Geol. Surv. 107, 1883–84.
	Springfield Coal-mine ..	Rep. N.Z. Geol. Surv. 25, 1885.
Crawford, J. C. ..	Geological Reports	Wellington Prov. Council Papers, pp. 17, 19, 30, 47–56.
	Essay on the Geology of the North Island	Dunedin, 1865, Trans. i. pt. 3; i. n.e. 305.
	On Boulders and Travelled Blocks in the Wellington Province	Trans. i. n.e. 19.

Author.	Title.	Name of Publication.
Crawford, J. C. ..	On Indications of Change in the Level of the Coast-line of the Southern Part of the North Island	Trans. i. 38.
	On Alluvial Gold in the Province of Wellington	„ ii. 160.
	On the Geology of the Port Nicholson District	Quart. Jrnl. Geol. Soc. xi. 530.
	On the Geology of the Province of Wellington (lecture)	Trans. ii. 343.
	Notes on the Miramar Peninsula, Wellington Harbour	„ v. 396.
	Port Nicholson and an Ancient Fresh-water Lake	„ vi. 290.
	Did the Great Cook Strait River flow to the North-west or South-east?	„ vii. 448.
	On the Probability of finding Extensive Coal-deposits within the Province of Wellington	„ viii. 379.
	On the Igneous Rocks of Wellington	„ viii. 375.
	On the Old Lake Systems of New Zealand, with some Observations on the Formation of the Canterbury Plains	„ viii. 369.
	On Probable Reasons why Few Fossils are found in the Upper Palæozoic and Possible Triassic Rocks of New Zealand	„ ix. 561.
	An Attempt at an Explanation of the Origin of Mineral Veins, particularly those of Gold and Silver	„ ix. 560.
	On Gold in the Wellington Provincial District	„ x. 477.
	On Wind-formed Lakes ..	„ xii. 415.
	On Bidwill's Front Hills ..	„ xii. 416.
	On Changes in the Hataitai Valley	„ xvii. 342.
	On Water-worn Pebbles in the Soil	„ xvii. 341.
Cussen, L. ..	Notes on the Physiography and Geology of the King Country	„ xx. 316.
	Thermal Activity in the Ruapehu Crater	„ xix. 374.
	Notes on the Piako and Waikato River Basins	„ xxvi. 398.
Cutten, W. H. ..	Origin and Progress of Gold-dredging in New Zealand	The Engineers' Mag. 1900; N.Z. Mines Record, iii. 352.
Daintree, R. ..	Notes on the Microscopical Structure of certain Igneous Rocks submitted by the Director of the Geological Survey of New Zealand	Trans. vii. 458.

Author.	Title.	Name of Publication.
Dana, James ..	Geology, chapter viii. ..	U.S. Exp. Exp. x. 437.
Darwin, Charles ..	Remarks on the Elevation of the Land; and as a Note: a Catalogue of Rocks met with at Bay of Islands	Geol. Obs. on Volcanic Islands, 142, 1844.
Davie, Cyrus ..	On the Earlier Earthquake Waves observed on the Coast of New Zealand	Trans. ii. 222.
Davis, E. H. ..	On the Geology of the Nelson Province	Rep. N.Z. Geol. Surv. 103, 1870–71.
	On a New Form of Iron-pyrites	Trans. iii. 287.
	Notes on the Thames Goldfields	Rep. N.Z. Geol. Surv. 56, 1870–71.
	On the Nomenclature of Rocks	Trans. iii. 285.
	Notes on Crystallized Sulphur from White Island	" iii. 285.
Davis, J. W. ..	Note on a Species of *Scymnus* from the Upper Tertiaries of New Zealand, Napier Series. Esk River (*S. acutus*)	Geol. Mag. 315, 1888.
De Lautour, H. A.	On the Fossil Marine Diatomaceous Deposit near Oamaru	Trans. xxi. 293.
Denniston, R. B.	Coal Exploration, Auckland District	Rep. N.Z. Geol. Surv. 114, 1876–77.
	Report on the Green Island Collieries	Rep. N.Z. Geol. Surv. 143, 1876–77.
	Detailed Notes on the Buller Coalfield	Rep. N.Z. Geol. Surv. 121, 1874–76.
Dieffenbach, Ernest	Travels in New Zealand, with Contributions to the Geography, Geology, Botany, and Natural History of that Country	1843.
	On the Geology of New Zealand (abstract)	Rep. Brit. Assoc. 50, 1845.
Dobson, A. D. ..	On the Traces of Ancient Glaciers in Nelson Province	Trans. iv. 336.
	On the Destruction of Land by Shingle-bearing Rivers, and Suggestions for Protection and Preservation	" iv. 153.
	On the Date of the Glacial Period: a Comparison of the Views represented in Papers published in the Transactions N.Z. Inst. v. and vi.	" vii. 440.
	Notes on the Glacial Period ..	" vi. 294.
	Description of a Remarkable Dyke on the Hills near Heathcote	" xiii. 391.
Don, J. R. ..	The Genesis of Ore-deposits ..	Trans. Aust. Inst. Mining Eng. xxvii.
Duncan, Professor M.	On some Fossil *Alcyonarians* from the Tertiary Deposits of New Zealand	Quart. Jrnl. Geol. Soc. xxxi. 675.
Dumerque, T. P. ..	Notes on the Eruption of Tarawera as observed at Opotiki	Trans. xix. 382.

Author.	Title.	Name of Publication.
Dunlop, Robert ..	The New Zealand Coal and Oil Company's Works at Orepuki	N.Z. Mines Record, iv. 219.
Etheridge, Robert, jun.	Note on the Volcanic Eruption in New Zealand	Geol. Mag. 398, 1886.
Enys, J. D. ..	On Sand-worn Stones from New Zealand	Quart. Jrnl. Geol. Soc. xxxiv. 86.
	Earthquake Disturbances in North Canterbury	N.Z. Jrnl. Sci. i. 176.
Ettingshausen, Constantin von	Contribution to the Knowledge of the Fossil Flora of New Zealand	Trans. xxiii. 237; Denksch. liii. pt. 1.
	Ueber die Genetische Gliederung der Flora Neu Seelande, 1883	Wien Akad. Sitzb. 1884, abth. i. 1203
	On the Fossil Flora of New Zealand	Geol. Mag. 363, 1887.
Field, H. C. ..	A Fossil Egg	N.Z. Jrnl. Sci. ii. 325.
	Notes on the Recent Earthquakes	Trans. xxx. 447.
Filhol, H. ..	Geological and Zoological Relations of Campbell Island with the Neighbouring Southern Lands	Acad. Sci. Paris, Feb. 27, 1882.
	Report on the Geology of the Campbell, Auckland, and Stewart Islands	Rep. Transit of Venus Exp. 1878.
Firth, J. C. ..	Deep-sinking in the Lava-beds of Mount Eden	Trans. vii. 460.
Forbes, H. O. ..	On Avian Remains found under Lava-flow near Timaru, Canterbury	„ xxiii. 366.
	On a Recent Discovery of the Remains of Extinct Birds in New Zealand	Nature, xlv. 416.
	On Subfossil Bones of Extinct Birds of New Zealand and Chatham Islands	„ xlvi. 404.
	Discovery of Cave Dwellings ..	„ xli. 209.
Forbes, Charles ..	On the Geology of New Zealand, with Note on its Carboniferous Deposits	Quart. Jrnl. Geol. Soc. xi. 521.
Forster, J. R. ..	Observations made on a Voyage round the World	Geol. of N.Z. 15–20, 1778.
Fox, C. E. ..	The Volcanic Beds of the Waitemata Series	Trans. xxxiii. 452.
Friedlander, B. ..	Some Notes on the Volcanoes of the Taupo District	„ xxxi. 498.
	Eruption of Te Mari	Nature, lxii. 180.
Galvin, P. ..	Handbook of New Zealand Mines. (Preface by Hon. W. J. Larnach)	1887.
Geikie, A. ..	Volcanic Eruptions in New Zealand	Contemp. Rev. i. 481; Living Age, liii. 408.
Gillies, R. ..	Account of a Visit to a Hot Spring called Te Puia, near Wangape Lake, Central Waikato	Trans. ii. 169.

Author.	Title.	Name of Publication.
Gold-Smith, E. C.	Description of Mayor Island, Bay of Plenty	Trans. xvii. 417.
Goodall, John ..	On the Formation of the Timaru Downs	„ xix. 455.
Gordon, H.F., and McKay, A.	Exploration in the Urewera Country	Mines Rep. C.–3, 1895.
Gordon, H. A. ..	The Hysteromorphous Auriferous Deposits of the Tertiary and Cretaceous Periods in New Zealand	Trans. Aust. Inst. Mining Eng. xxv. 292.
	Outline History of the Coal, Gold, and other known Mineral Resources of New Zealand	Mines Dept. Rep. 1886.
	On the Source of Gold and other Metals	N.Z. Inst. Mining Eng. 1898; abst. in N.Z. Mines Record, ii. 16.
Griffiths, G. S. ..	A Glacial Epoch in the Southern Hemisphere	Melb. Rev. Oct. 1885, 403.
Guppy, R. Lechmere	Kitchen Middens of New Zealand	The Geologist, vi. 65.
Haast, Sir J. von ..	Report of a Geological Survey of Mount Pleasant	Dec. 19, 1860.
	Report of a Topographical and Geological Exploration of the Western Districts of the Nelson Province	Nelson, Jan. 1, 1861.
	Notes on the Geology of the Province of Canterbury	Gov. Gaz. Prov. of Cant. ix. No. 18, Oct. 24, 1862.
	Report of the Provincial Geologist on the Coal-measures and Lignitiferous Beds of the River Kowhai	Gov. Gaz. Prov. of Cant. x. No. 15, Sept. 3, 1863; xi. No. 8, Sept. 23.
	Discovery of a Favourable Pass to the Sea above Lake Wa-	Cant. newspapers, April 1, 1863.
	On the Practicability of supplying Christchurch with Pure Water by means of Artesian Wells	Cant. newspapers, June 19, June 26, 1863.
	Report on the Malvern Hills Coalfield	N.Z. Gaz. Sept. 23, 1863.
	Report of the Geological Survey of the Province of Canterbury	Proc. Prov. Council Cant. Sess. xxii., Aug. 2, 1864.
	Notes on the Mountains and Glaciers of Canterbury	Geogr. Soc. Jrnl. xxxiv. 87, 1864.
	Report on the Building-stones of the Province of Canterbury (first series)	Christchurch papers, Feb. 4 and 5, 1864.
	Report on the Formation of the Canterbury Plains, with a Map and Five Sections	Proc. Prov. Council of Cant. Sess. xxii. 1864.
	Glacial Deposits in New Zealand	Nat. Hist. Rev. July, 1864.
	On Recent Discoveries in New Zealand	Nat. Hist. Rev. Jan. 1864.

Author.	Title.	Name of Publication.
Haast, Sir J. von..	Report on the Geological Formation of the Timaru District in reference to a Supply of Water	Christchurch, 1865.
	Reports on the Geological Exploration of the West Coast: (*a*) Lake Sumner; (*b*) Hokitika; (*c*) Mouth of Teremakau; (*d*) Hokitika	Proc. Prov. Council of Cant. Sess. xxiv. April 6, April 22, May 4, May 6, 1865.
	Report on the Geological Exploration of the West Coast	Proc. Prov. Council of Cant. Sess. xxiv. July 24, 1865.
	Report on the Head-waters of the River Waitaki	Prov. Council, Aug. 24, 1865.
	Lecture on the West Coast of Canterbury delivered to Members of the Mechanics' Institute	Christchurch, Sept. 25, 1865.
	Table of Altitudes from Christchurch to Hokitika by Arthur's and Browning's Passes	Proc. Prov. Council of Cant. Sess. xxiv. Nov. 18, 1865.
	Notes on the Causes which have led to the Excavation of Deep Lake-basins in Hard Rocks in the South of New Zealand	Quart. Jrnl. Geol. Soc. xxi. 130; Phil. Mag. xxix. 158.
	Notes on a Sketch-map of the Province of Canterbury showing the Glaciation during the Pleistocene and Recent Periods as far as explored (1864)	Quart. Jrnl. Geol. Soc. xxi. 133; Phil. Mag. xxix. 159.
	Notes on the Climate of the Pleistocene Epoch of New Zealand	Phil. Mag. xxix. 398.
	Report on the Head-waters of the River Rakaia, with Twenty Illustrations and Two Appendices	Christchurch, June 20, 1866.
	Report on the Timaru Water-supply, No. 11	Jan. 2, 1866.
	Altitude Sections of the Principal Routes between the East and West Coasts of the Province of Canterbury, New Zealand, across the Southern Alps	Geogr. Soc. Jrnl. xxxvii. 328.
	Notes on the Geology of the Province of Canterbury, New Zealand, principally in reference to the Deposits of the Glacial Epoch at the Western Base of the Southern Alps	Quart. Jrnl. Geol. Soc. xxxiii. 342; Phil. Mag. xxxiv. 399.
	Notes on the Rev. J. E. Tenison-Woods's Paper "On the Glacial Epoch in Australia"	Trans. Roy. Soc. Vict. viii. 273.
	On Earthquakes on Land and Sea	Christchurch newspapers, Oct. 23, 1868; Trans. i. 106, 147 n.s.

Author.	Title.	Name of Publication.
Haast, Sir J. von..	Notes on the Rock Specimens collected by H. H. Travers on Chatham Islands	Trans. i. 180.
	Beschreibung einer Reise von Christchurch nach den Goldfeldern der W. Kuste in 1865	Wien, Mittheil. Geog. Gesell. xi. 132, 157, 189–194, 1868.
	Report of Dr. Haast, Provincial Geologist, on the Completion of the Topographical and Geological Survey of the Province of Canterbury (final report)	Proc. Prov. Council of Cant. Sess. xxx. 1868.
	Saurian Remains from the Waipara River, Canterbury, in the Possession of J Cockburn-Hood	Trans. ii. 186.
	On the Geology of the Waipara District of Canterbury, with Geological Map and Sections	Geol. Surv. Rep. No. 6, 1870–71.
	Saurien in der Tertiarform. in New Zealand	Wien, Verhandl. Geol. 350, 1869.
	Notes on the Thermal Springs in the Hanmer Plains, Province of Nelson	Trans. iii. 293; Petermann Mittheil. xvii. 95, 1871.
	Geologie aus Neu Seeland ..	Wien, Verhandl. Geol. 246, 1870.
	Notes on the Geology of the Central Portion of the Southern Alps, including Mount Cook	Geol. Surv. Rep. No. 6, 19, 1870–1.
	On the Geology of the Amuri District in the Provinces of Nelson and Marlborough	Geol. Surv. Rep. No. 6, 25, 1870–71.
	On the Geology of the Waipara District, Canterbury	Geol. Surv. Rep. 5, 1870–71.
	Preliminary Report on the Malvern Hills, Canterbury	Geol. Surv. Rep. No. 6, 135, 1870–71.
	Report on the Geology of the Malvern Hills	Geol. Surv. Rep. No. 7, 1, 1871–72.
	Report on the Coal-deposits of the Ashburton District, Canterbury	Geol. Surv. Rep. No. 7, 141, 1871–72.
	Report on the Shag Point Coalfields, Otago	Geol. Surv. Rep. No. 7, 148, 1871–72.
	Preliminary Report and Memorandum of Practical Suggestions concerning the Malvern Hills Coal mine, Canterbury	Prov. Govt. of Cant. July 5, 1871.
	Notes on the Geology of the Glentui, a Branch of the Ashley River	Geol. Surv. Rep. No. 7, 85, 1871–72.
	Notes on the Geology of the Clent Hills and Mount Somers District, 21st February, 1873	Geol. Surv. Rep. No. 8, 1, 1872–73.
	Notes to accompany a Geological Map and Sections of the Shag Point District, Otago, 21st February, 1873	Geol, Surv. Rep. No. 8, 19, 1872–73.

Author.	Title.	Name of Publication.
Haast, Sir J. von..	On the Geology of the Canterbury Plains	Trans. vi. 419.
	Vorkommen von Brachiopoden im den Kusten von Neu Seeland	Wien, Geol. Verhandl. 253, 1874.
	Recent Cavern Researches in New Zealand	Nature, xiv. 576.
	Geology of the Provinces of Canterbury and Westland	Christchurch, 1879; Geol. Mag., 1880, 41 (Review by J. M.).
	New Zealand Prehistoric Skeleton	Nature, xiv. 90.
	Erosion of River-banks, in President's Address	Trans. x. 37.
	On the Geological Structure of Banks Peninsula	„ xi. 495.
	On the Progress of Geology ..	N.Z. Jrnl. Sci. i. 395.
	On the So-called Hart's Coalfield in the Malvern Hills	Geol. Surv. Rep. No. 16, 16, 1883–84.
	Further Notes on the Thermal Springs in the Hanmer Plains	Trans. xiv. 414.
	On the Geological Structure of the Southern Alps of New Zealand in the Provinces of Canterbury and Westland	„ xvii. 332.
	Notes on the Age and Subdivision of the Sedimentary Rocks in the Canterbury Mountains, based upon the Palæontological Researches of Von Ettingshausen	„ xix. 449.
	The Mineral Resources of New Zealand	Aust. Times and Anglo-New-Zealander, Suppl. 1, Aug. 13, 1886.
Haeuster, R. ..	On the Microscopical Structure of New Zealand Gold	Trans. xxiii. 335.
Hamilton, A. ..	On the Foraminifera of the Tertiary Beds at Petane, near Napier	„ xiii. 393.
	On the Septarian Boulders of Moeraki, Otago	„ xxxiii. 447.
Hamilton, W. S...	On the Formation of the Quartz Pebbles of the Southland Plains	„ xv. 414.
	Notes on the Geology of the Bluff District	„ xix. 452.
Hardcastle, J. ..	On the Cause of Volcanic Action	„ xix. 338.
	The Tarawera Eruption, 10th June, 1886: a Criticism of Professor Hutton's (and Others') Explanations of the Cause of the Eruption	„ xx. 277.
	Origin of the Loess Deposit of	„ xxii. 406.

Author.	Title.	Name of Publication.
Hardcastle, J. ..	On the Drift in South Canterbury	Trans. xxiii. 311.
	On the Timaru Loess as a Climate Register	" xxiii. 324.
	On Glacier Motion	" xxiii. 332.
Harris, G. F. ..	British Museum Catalogue: Tertiary Fossils, New Zealand Section	1897.
Hayes, F. ..	Explosions in Coal-mines ..	N.Z. Mines Record, i. 205.
Hazard, H. D. M.	The Thermal Springs in Lake Waikare, Waikato	Trans. xxiii. 527.
Heaphy, C. ..	On the Volcanic Country of Auckland	Quart Jrnl. Geol. Soc. xvi. 242; Southern Mo. Mag. 1860.
	On the Gold-bearing District of Coromandel Harbour, New Zealand	Quart. Jrnl. Geol. Soc. xi. 31.
	On the Coromandel Gold-diggings, New Zealand	Quart. Jrnl. Geol. Soc. x. 324.
Hector, Sir James	Notes relative to the Geology of the Manuherikia Valley	Otago Prov. Govt. Gaz. 85, Sept. 3, 1862.
	Report of Progress of Geological Survey of Otago since 15th April, 1862	Otago Prov. Govt. Gaz. 217, 1862.
	Geological Expedition to the West Coast of Otago, New Zealand: Report, with Appendix of Meteorological Observations taken on the West Coast of Otago	Otago Prov. Govt. Gaz. 435, Nov. 5, 1863.
	Departmental Report of the Geological Survey of Otago, 13th April, 1864. Report on Coals of Otago and other Parts of New Zealand	1864.
	On the Geology of the Province of Otago, New Zealand	Geol. Mag. 233, 1864; Quart. Jrnl. Geol. Soc. xxi. 124; Phil. Mag. xxix. 157.
	Expedition to the West Coast of Otago, New Zealand, with an Account of a Low Pass from Martin's Bay to Whakatipu	Jrnl. Roy. Geogr. Soc. xxxiv. 96; Proc. Roy. Geogr. Soc. viii. 47, ix. 32.
	Origin of Rock Basins in New Zealand	Geol. Mag. ii. 377.
	First General Report on the Coal-deposits of New Zealand, with List of Principal Special Reports on the Coal-deposits of New Zealand which have appeared in the Government *Gazette*	Rep. N.Z. Geol. Surv. 1866.

Author.	Title.	Name of Publication.
Hector, Sir James	*Abstract Reports of the Progress of the Geological Survey of New Zealand	Rep. N.Z. Geol. Surv. 1868 to date.
	Notes on Rocks and Minerals mentioned in Captain Hutton's Report on Thames Goldfield	Rep. N.Z. Geol. Surv. 39, 1869.
	Memorandum to accompany Geological Sketch-map of Kawau	Rep. N.Z. Geol. Surv. 45, 1869.
	A Further Notice of the Earthquake Wave (1st February, 1868); also on those of 14th to 18th August	Trans. i. n.e. 46, 93.
	On the Recent Earthquakes and Wave-phenomena observed in New Zealand	„ i. n.e. 35, 47.
	Notes on the Geology of the Outlying Islands of New Zealand, with Extracts from Official Report	„ ii. 176.
	On Mining in New Zealand (Abstract of Lectures delivered at Colonial Museum, Wellington, 24th and 31st July; 21st and 28th August), (Maps and Plans)	„ ii. 361.
	Preliminary Note on the Bones of a Fossil Penguin	„ ii. 403.
	The Glacial Epoch in New Zealand	Geol. Mag. vii. 95.
	Leading Features of the Geology of the Kaimanawa and Ruahine Ranges	Trans. iii. 16.
	Notes on the Geology of White Island	„ iii. 278.
	Notes on the Thermal Springs of the Hanmer Plain	„ iii. 297.
	On the Geological Structure of the Malvern Hills District	Rep. N.Z. Geol. Surv. 46, 1870–71.
	On the Geology of the Cape Colville District	Rep. N.Z. Geol. Surv. 88, 1870–71.
	Notes on the Geology of Hawke's Bay District	Rep. N.Z. Geol. Surv. 159, 1870–71.
	On the Remains of a Gigantic Penguin (*Palæeudyptes antarcticus*, Huxley) from the Tertiary Rocks on the Coast of Nelson	Trans. iv. 341.

* Abstracts of the work done by the officers of the Survey, and the bearing on the general geology of the country of the facts observed year by year, appear at the commencement of each report, and form very important documents. These should all appear under the name of Sir James Hector.

Author.	Title.	Name of Publication.
Hector, Sir James	On Recent Moa Remains in New Zealand	Nature, 184, July 6, 1871.
	Report on the Gold-mines in the Province of Marlborough	Rep. N.Z. Geol. Surv. 119, 1871-72.
	Report on the Coal-mines in the Western District of the Province of Nelson	Rep. N.Z. Geol. Surv. 129, 1871–72.
	Further Report on the Malvern Hills Coal, Canterbury	Rep. N.Z. Geol. Surv. 146, 1871–72.
	Report on the Coal-seams at Whangaroa and Mongonui, Auckland	Rep. N.Z. Geol. Surv. 153, 1871–72.
	Report on the Collingwood Mine, Nelson	Rep. N.Z. Geol. Surv. 158, 1871–72.
	Report on the Clutha and Green Island Coalfields	Rep. N.Z. Geol. Surv. 165, 1871–72.
	General Report on the Coals of New Zealand	Rep. N.Z. Geol. Surv. 172, 1871–72.
	Further Notes on the Bones of a Fossil Penguin (*Palæeudyptes*)	Trans. v. 438.
	Fossil Reptilia of New Zealand	" vi. 333.
	On the Geology of New Zealand, with special reference to the Drift of that Country (abstract)	Nature, 258, Jan. 27, 1876.
	Kaitangata Coal-mine: Memorandum and Plan	Rep. N.Z. Geol. Surv. 140, 1876–77.
	On a New Trilobite (*Homalonotus expansus*)	Trans. ix. 602.
	On the Belemnites found in New Zealand	" x. 484.
	The Ototara Series, New Zealand	Geol. Mag. 135, 1877.
	On the Fossil Flora of New Zealand (abstract)	Trans. xi. 536.
	On the Fossil *Brachiopoda* of New Zealand (abstract)	" xi. 537.
	On the Relative Ages of the Australian, Tasmanian, and New Zealand Coalfields (abstract)	Nature, 112, 1878.
	On a Deposit of Chalk recently discovered near Oxford, in Canterbury	Trans. xii. 439.
	Handbook of New Zealand (Melbourne International Exhibition): Geology	2nd ed. 19–52, 1880.
	Catalogue of Collection of Fossils illustrating the Geology of New Zealand	Appendix to Official Catalogue, Sydny Exhibition, 1879.
	Report on Chrome-ores ..	Rep. N.Z. Geol. Surv. 1, 1881.
	Index to Fossiliferous Localities in New Zealand	Rep. N.Z. Geol. Surv. 118, 1881.
	Naseby Deep-sinking	Rep. N.Z. Geol. Surv. 44, 1883–84.

Author.	Title.	Name of Publication.
Hector, Sir James	On the Geological Structure of the Canterbury Mountains	Trans. xvii. 337.
	Coal Strata in Palmerston South	Rep. N.Z. Geol. Surv. 182, 1885.
	Outlines of New Zealand Geology, with Map. Second Part of Special Catalogue of Geological Exhibits sent to Indian and Colonial Exhibition. Also Appendix to General Index to Reports of Geological Survey	Rep. N.Z. Geol. Surv. 37, 1886.
	On the Mokihinui Coalfield ..	Rep. N.Z. Geol. Surv. 156, 1886–87.
	Index to Fossiliferous Localities in New Zealand	Rep. N.Z. Geol. Surv. 255, 1886–87.
	On the Recent Volcanic Eruption at Tarawera	Rep. N.Z. Geol. Surv. 240, 1886–87.
	Index to the Reports of the Geological Survey of New Zealand, from 1866 to 1885 inclusive	1887.
	Presidential Address at Australasian Association for the Advancement of Science (Christchurch, New Zealand)	Nature, 521, April 2, 1891.
	Minerals of New Zealand ..	Rep. N.Z. Geol. Surv. 105, 1890–91.
	Index to Fossiliferous Localities in New Zealand distinguished by Numbers	Rep. N.Z. Geol. Surv. 120, 1890–91.
	Index to Fossiliferous Localities according to Counties	Rep. N.Z. Geol. Surv. 146, 1890–1.
	New Zealand Geological Sketch-map, constructed from Official Surveys and the Explorations of Dr. F. von Hochstetter, Dr. J. von Haast, and Others	Wellington, 1873; published, 1874.
Hector, Sir J., and A. McKay	Iron Ores and Sands of New Zealand (from Handbook, New Zealand, 1886), and Further Notes on the Iron Ores of New Zealand, by A. McKay	N.Z. Mines Record, iii. 472.
Hill, H. ..	Geology of Scinde Island and the Relation of the Napier Limestone to Others in the Surrounding District	Trans. xix. 441.
	Traces of Volcanic-dust Showers at Napier, Petane, and generally throughout the East Coast Districts North of Cape Kidnapper	" xix. 385.
	Description of a Scaphites found near Cape Turnagain	" xix. 387.
	On the Artesian-well System of Hawke's Bay	" xx. 282.

Author.	Title.	Name of Publication.
Hill, H. ..	Pumice: its Geological Distribution on the East Coast of the North Island of New Zealand, extending from Tolaga Bay to Cape Turnagain	Trans. xx. 293.
	The Oil Prospects of Poverty Bay and the District	" xxi. 320.
	Descriptive Geology of the District between Napier and Ruapehu Mountain *viâ* Kuripapanga and Erewhon	" xxii. 422.
	Artesian Wells (No. 2) ..	" xx. 429.
	On the Relations of the Kidnappers and Pohui Conglomerates to the Napier Limestones and Petane Marls	" xxiii. 340.
	Ruapehu and Ngauruhoe ..	" xxiv. 603.
	Geological Time	" xxiv. 717.
	Artesian-water Prospects at Wanganui	" xxv. 343.
	Artesian Wells, Wanganui, New Zealand	" xxv. 348.
	Discovery of Artesian Water-supply at Ruataniwha Plains	" xxv. 350.
	The Volcanic Outburst at Te Mari, Tongariro, in November, 1892	" xxvi. 388.
	Notes on the Geology of the Country between Dannevirke and Wainui, Hawke's Bay	" xxvi. 392.
	On the Hawke's Bay Pleistocene Beds and the Glacial Epoch	" xxvii. 451.
	On the Occurrence of Moa Footprints in the Bed of the Manawatu River near Palmerston North	" xxvii. 476.
	The Nuhaka Hot Springs (Morere)	" xxvii. 478.
	Denudation as a Factor of Geological Time	" xxviii. 666.
	Ruapehu and the Volcanic Zone in 1895 (No. iv.)	" xxviii. 681.
	On Artesian-water Prospects in Poverty Bay and Gisborne	" xxix. 567.
	On a Volcanic-dust Shower in Napier	" xxix. 571.
	On the Geology of the District between Napier and Puketitiri	" xxxii. 183.
	Tongariro, Ngauruhoe, and Ruapehu as Volcanic Cones	Aust. Assoc. Adv. Sci. iii 162.
Hochstetter, Ferd. von	Lecture on the Geology of the Province of Nelson	Nelson Gazette, Oct. 22, 1859.
	Bericht ueber Geologie untersuchungen in der Prov. Auckland	Sitz. Akad. der Wissenschaft. zu Wien, xxxvii. 123.

Author.	Title.	Name of Publication.
Hochstetter, Ferd. von	Report of a Geological Exploration of the Coalfields in the Hunua and Drury Districts, in the Province of Auckland	N.Z. Gazette, Nos. 9–12, 1859.
	The Pakawau Coalfields ..	Nelson Gazette, vii. No. 20, 97, 1859.
	Ueber die Vulkane Neu Seeland,	Ausland, No. 46, 1859.
	Dunit, Korniger Olivinfels von Dun Mountain bei Nelson	Deutsch. Geol. Gesellsch. Zeitschr. xvi. 341, 1864.
	Tabellarische Ueberschecht der gemengten Massengesteine, Neu Seeland	Neues Jahrb. Mineral. 697, 1864.
	Ueber das Vorkommen und die Neu Seelandischen Nephrit (Punamu der Maoris)	Wien Akad. Sitz. xlix. 466, 480, 1864; Wien Anzeiger, i. 82, 1864.
	Der Franz-Joseph Gletscher in der Sudlichen Alpen Neu Seelands	Ausland, 1867; Wien Mitt. Geog. Gesell. (abth.) 57, 1868.
	New Zealand: its Physical Geography, Geology, and Natural History. (Translated by Sauter)	Stuttgart, 1867.
	Geologie von Neu-Seeland: Beitrage zur Geologie der Provinzen Auckland und Nelson	"Novara" Exp. Geolog. Theil, i. band, 1 abth.; Neues Jahrb. Mineralog. 874, 1865.
	Ueber den Ban der Vulkane auf Neu Seeland	Ausland, 1865.
	Palæontologie von Neu Seeland. By Unger, Zittel, Suess, Karrer, Stoliczka, Stache, and Jaeger	Reise der "Novara," 2 abth. 1864.
Hochstetter, Ferd. von, and Mundy, D. L.	Rotomahana and the Boiling Springs of New Zealand: Sixteen Views and Descriptive Notes	Review in Nature, Oct. 21, 582, 1875.
Hochstetter, Ferd. von, and Petermann, A.	The Geology of New Zealand, in Explanation of the Geographical and Topographical Atlas of New Zealand. (Translated by Dr. C. F. Fischer)	Auckland, 1864.
Holland, Philip ..	Analysis of Hauraki Rhyolite ..	Quart. Jrnl. Geol. Soc. lv. 467.
Hunter, Ashley ..	Direct Evidence of a Change in the Elevation of the Waikato District.	Trans. xvi. 459.
Hutton, Captain F. W.	On the Lower Waikato District	Rep. N.Z. Geol. Surv. 1867.
	On the Thames Goldfields ..	Ditto.
	On the Geology of the Island of Pakihi	Trans. i. 113; i. n.e. 167.
	Notes on the Basin of Te Tarata, Rotomahana	" i. 162; i. n.e. 106.

Author.	Title.	Name of Publication.
Hutton, Captain F. W.	Remarks on the Earthquake Wave (August, 1868)	Trans. i. 100.
	On the Geology of the North Head of Manukau Harbour	" ii. 161.
	Description of Nga Tutura, an Extinct Volcano in New Zealand	Quart. Jrnl. Geol. Soc xxv. 13; Phil. Mag. xxxviii. 73.
	Report on Great Barrier Island	Rep. N.Z. Geol. Surv. 1, 1869.
	Report on East Cape District ..	Rep. N.Z. Geol. Surv. 7, 1869.
	Report on Okarito District ..	Rep. N.Z. Geol. Surv. 8, 1869.
	Second Report on the Thames Goldfields	Rep. N.Z. Geol. Surv. 15, 1869.
	On a Carbonaceous Mineral from Whangarei Harbour	Trans. iii. 250.
	On the Relative Ages of the Waitemata Series and the Brown-coal Series of Drury and Waikato	" iii. 244.
	On the Artesian Wells near Napier	" iii. 251.
	On the Occurrence of Native Mercury near Pakaraka, Bay of Islands	" iii. 251.
	On a Coal-seam discovered near Maramarua Creek, Waikato	Rep. N.Z. Geol. Surv. 1, 1870–71.
	On the Geology of Coromandel	Rep. N.Z. Geol. Surv. 2, 1870–71.
	Report on the Caledonian Mine, Thames Goldfields	Rep. N.Z. Geol. Surv. 146, 1870–71.
	Report on the Collingwood Company's Coal-mine	Rep. N.Z. Geol. Surv. 157, 1870–71.
	Report on the Perseverance Company's Gold-mine, Collingwood	Rep. N.Z. Geol. Surv. 151, 1870–71.
	On the Alluvial Deposits of the Lower Waikato and the Formation of Islands by the River	Trans. iv. 333.
	Reports on the Geology of Southland	Rep. N.Z. Geol. Surv. 89, 1871–72.
	Report on the Northern Coalfields	Rep. N.Z. Geol. Surv. 112, 1871–72.
	Synopsis of the Younger Formations of New Zealand	Rep. N.Z. Geol. Surv. 182, 1871–72.
	On the Date of the Last Great Glacier Period in New Zealand and the Formation of Lake Wakatipu	Trans. v. 384.
	On the Formation of Lake Wakatipu	" v. 394.
	Lecture on the Formation of Mountains	" v. xxv.

Author.	Title.	Name of Publication.
Hutton, Captain F. W.	On the Phenomena of the Elevation and Subsidence of the Earth	Phil. Mag. xliv. 401.
	Report on the Geology of the North-east Portion of the South Island	Rep. N.Z. Geol. Surv. 27, 1872–73.
	Synopsis of the Younger Formations of New Zealand	Quart. Jrnl. Geol. Soc. xxix. 372.
	Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand in the Collection of the Colonial Museum	1873.
	On the Formation of Mountains	Trans. vi. 264.
	On the Geological Structure of the Thames Goldfields	" vi. 272.
	On the Formation of Mountains: a Reply to the Rev. O. Fisher	" vi. 284.
	Description of Three New Tertiary Shells in the Otago Museum (*Cominella striata*, Wanganui; *Zizyphinus hodgei*, Wanganui; *Venus sulcata*, Napier Limestone)	" vii. 458.
	On the Cause of the Former Great Extension of the Glaciers in New Zealand	" viii. 383.
	On the Relation between the Pareora and the Ahuriri Formations	" ix. 590.
	On the Reptilian Beds of New Zealand	" ix. 581.
	Description of some New Tertiary Mollusca from Canterbury	" ix. 593.
	What is an Earthquake? ..	N.Z. Jrnl. Sci. i. 3.
	Has the Deep Ocean ever been Dry Land?	" i. 406.
	Description of some New Tertiary Shells from Wanganui	Trans. xv. 410.
	Note on the Silt-deposit at Lyttelton	" xv. 411.
	On the Lower Gorge of the Waimakariri	" xvi. 449.
	On the Orakei Bay Beds, near Auckland	" xvii. 307.
	Description of New Tertiary Shell	" xvii. 313.
	On the Geology of Scinde Island	" xviii. 327.
	New Species of Tertiary Shells	" xviii. 333.
	The Wanganui System ..	" xviii. 336.
	Oxford Chalk Foraminifera ..	N.Z. Jrnl. Sci. ii. 565.
	Sketch of the Geology of New Zealand	Quart. Jrnl. Geol. Soc. xli. 191.
	General Geology of New Zealand	Nature, xxxi. 305.

Author.	Title.	Name of Publication.
Hutton, Captain F. W.	Sketch of the Geology of New Zealand (abstract of paper in Geological Society of London, 1885)	N.Z. Jrnl. Sci. ii. 435, 486.
	On the Geological Position of the Weka Pass Stone	Quart. Jrnl. Geol. Soc. xli. 266.
	Correlations of the Curiosity-shop Beds, Canterbury, New Zealand	Quart. Jrnl. Geol. Soc. xli. 547.
	Source of Gold at the Thames ..	N.Z. Jrnl. Sci. iii. 146.
	On the Geology of the Trelissick or Broken River Basin, Selwyn County	Trans. xix. 392.
	On the So-called Gabbro of Dun Mountain	" xix. 412.
	On the Geology of the Country between Oamaru and Moeraki	" xix. 415.
	Note on the Geology of the Valley of the Waihao, in South Canterbury	" xix. 430.
	Report on the District traversed by the New Zealand Midland Railway, Christchurch	Sep. pub. Christchurch.
	On some Railway-cuttings in the Weka Pass	" xx. 257.
	On the Greensands of the Waihao Forks	" xx. 264.
	On some Fossils recently obtained from the Cobden Limestone at Greymouth	" xx. 267.
	On some Ancient Rhyolite from the Mataura District	" xx. 269.
	On a Hornblende-biotite Rock from Dusky Sound, New Zealand	Quart. Jrnl. Geol. Soc. xliv. 745.
	Life on the Earth (abstract) ..	Aust. Assoc. Adv. Sci. vii. 340.
	On the Rocks of the Hauraki Goldfields	Aust. Assoc. Adv. Sci. i. 245.
	The Eruptive Rocks of New Zealand	Jrnl. R.S. of N.S.W. xxiii. 102.
	The Earthquakes at the Amuri	Trans. xxi. 269.
	Notes on the Relative Ages of the New Zealand Coalfields	" xxii. 377.
	Note on the Geology of the Country about Lyell	" xxii. 387.
	Note on the Eruptive Rocks of the Bluff Peninsula, Southland	" xxiii. 353.
	On the Foliated Rocks of Otago	" xxiv. 359.
	Notes on the Boulders in the Port Hills, Nelson	" xxiv. 365.
	On a New Plesiosaur from the Waipara River	" xxvi. 347.
	On *Conchothyra parasitica* ..	" xxvi. 358.
	Corrections of the Names of some New Zealand Rocks	" xxxi. 483.

Author.	Title.	Name of Publication.
Hutton, Captain F. W.	On a Supposed Rib of the Kumi	Trans. xxxi. 485.
	On the Footprint of a Kiwi-like Bird from Manaroa	" xxxi. 486.
	The Geological History of New Zealand	" xxxii. 159.
Hutton, Captain F. W., and Gray, G.	On a Leucophyre from the Selwyn Gorge	" xx. 271.
Hutton, Captain F. W., and Kirk, T. W.	Description of Arid Island, Hauraki Gulf	" i. 108; i. n.e. 163.
Hutton, Captain F. W., and Ulrich, G. H. F.	Report on the Geology and Gold-fields of Otago. Review by J. M.	Nature, xiv. 146, 1875; Geol. Mag. 178, 1880.
Huxley, Professor T. H.	On a Fossil Bird and a Fossil Cetacean from New Zealand: *Palæeudyptes antarcticus*, Kakanui Limestone; *Phocænopsis mantelli*, Awamoa (Parera)	Quart. Jrnl. Geol. Soc. xv. 671.
Johnston-Lavis, H. J.	The Volcanic Eruption of New Zealand	Geol. Mag. 523, 1886.
Jaquet, J. B. ..	Gold-dredging in New Zealand	Bulletin, Mines Dept N.S.W. 1898; N.Z. Mines Record, ii. 60.
Keddell, Jackson..	Report on Hartley and Riley's Diggings	Otago Prov. Govt. Gaz. Sept. 3, 1862.
Kirk, T. W. ..	Description of New Tertiary Fossils	Trans. xiv. 409.
Knight, Charles ..	On the Teeth of the *Leiodon* ..	" vi. 358.
Kolenko, B. ..	Eruptive Rocks from Banks Peninsula	Neues Jahrbr. fur Mineral. i. 1, 1885; N.Z. Jrnl. Sci. i. 548.
Law, W. ..	Report on the Comparative Values of Coals (Auckland District)	Rep. N. Z. Geol. Surv. 139, 1876–77.
Laing, R. M. ..	A Few Notes on the Thermal Springs at Lyttelton	Trans. xvi. 447.
Lendenfeld, R. von.	Der Tasman Gletscher ..	Geology, 50, 1884.
Leys, Thompson W.	The Volcanic Eruption of Tarawera	Auckland, 1886.
Lindop, A. B. ..	Malvern District Coal-mines ..	Rep. N.Z. Geol. Surv. 15, 1885.
	Waihao Coalfield	Rep. N.Z. Geol. Surv. 21, 1885.
	Springfield Colliery	Rep. N.Z. Geol. Surv. 25, 1885.
	Acheron Coal-mine	Rep. N.Z. Geol. Surv. 13, 1885.
Lindsay, Dr. Lauder	On Specimens illustrating the Geology and Mineralogy of New Zealand (exhibited at Royal Society, Edinburgh)	The Geologist, vi. 143.
Liversidge, Prof. A.	On the Crystalline Structure of Gold Nuggets from Klondyke, Victoria, and New Zealand	Nature, lxv. 192.

Author.	Title.	Name of Publication.
Liversidge, Prof. A.	Analysis of Slate in Contact with Granite from Preservation Inlet, New Zealand	Trans. xvii. 340.
	Analysis of a Rock Specimen showing the Junction between Granite and Slate	„ x. 505.
	Note on some New Zealand Minerals belonging to Otago Museum, Dunedin	„ x. 490.
M. D.	Dredging on the West Coast of New Zealand: Suggestions as to other Methods of winning the Gold	N.Z. Mines Record, iii. 470.
Macfarlane, D. ..	Notes on the Geology of the Jackson and Cascade Valleys	Rep. N.Z. Geol. Surv. 27, 1876–77.
Maclaren, J. M. ..	On Occurrences of Gold in the Coromandel District	Trans. xxxi. 492.
	On the Geology of Te Mochau..	„ xxxi. 494.
	Castle Rock, Coromandel ..	„ xxxii. 213.
McLeod, H. N. ..	On Caves in the Martinborough District, and Moa-bones found therein (abstract)	„ xxxiv. 562.
Macleod, W. A. ..	Notes on a West Coast Dolerite	„ xxxi. 487.
	Notes on a Hypersthene Andesite from White Island	„ xxxi. 488.
	Notes on a Hornblende Trachyte from Tawhetarangi	„ xxxi. 490.
	Minerals occurring on the Coromandel Goldfield	N.Z. Mines Record, iv. 172; Parl. Paper C.–9, 1900.
Mackay, Thomas	The Glacial Period of New Zealand	Trans. vii. 447.
Mackinnon, W. M.	Gold-dredging in New Zealand	Brit.Columb. Mining Rec. Dec. 1899; N.Z. Mines Record, iii. 340.
McKay, A. ..	Reports relative to Collection of Fossils in South-east District of Otago: Caversham to Catlin's River	Rep. N.Z. Geol. Surv. 59, 1872–3.
	Reports relative to Collection of Fossils made on the West Coast of the South Island	Rep. N.Z. Geol. Surv. 74, 1872–73.
	Reports relative to Collection of Fossils made in East Cape District, North Island	Rep. N.Z. Geol. Surv. 116, 1872–73.
	Reports on Coal-measures at Shakespeare Bay, Picton	Rep. N.Z. Geol. Surv. 32, 1874–76.
	Report on Whangaroa North ..	Rep. N.Z. Geol. Surv. 35, 1874–76.
	Report on Weka Pass and Buller Districts	Rep. N.Z. Geol. Surv. 36, 1874–76.
	Report on Country between Cape Kidnappers and Cape Turnagain	Rep. N.Z. Geol. Surv. 43, 1874–76.
	Report on Tertiary Rocks at Makara	Rep. N.Z. Geol. Surv. 54, 1874–76.

Author.	Title.	Name of Publication.
McKay, A. ..	Report on Kaikoura Peninsula and Amuri Bluff	Rep. N.Z. Geol. Surv. 172, 1874–76.
	Report on Cape Campbell District	Rep. N.Z. Geol. Surv. 185, 1874–76.
	On the Reptilian Beds of New Zealand	Trans. ix. 581.
	Report on the Oamaru and Waitaki Districts	Rep. N.Z. Geol. Surv. 41, 1876–77.
	Report on Country between Masterton and Napier	Rep. N.Z. Geol. Surv. 67, 1876–77.
	On the Occurrence of Gold in the Mackenzie Country	Trans. x. 481.
	Report on the Occurrence of Moa-bones at Taradale, near Napier, Hawke's Bay	Rep. N.Z. Geol. Surv. 64, 1878–79.
	Report on the Geology of the District between Waipukurau and Napier	Rep. N.Z. Geol. Surv. 69, 1878–79.
	Report on the Southern Part of the East Wairarapa District	Rep. N.Z. Geol. Surv. 75, 1878–79.
	Report on the District between Kaituna Valley and Queen Charlotte Sound	Rep. N.Z. Geol. Surv. 86, 1878–79.
	Report on the District between the Wairau and Motueka Valleys	Rep. N.Z. Geol. Surv. 97, 1878–79.
	Reports on the Baton River and Wangapeka District and Mount Arthur Range	Rep. N.Z. Geol. Surv. 121, 1878–79.
	Report on the Geology of the Neighbourhood of Wellington	Rep. N.Z. Geol. Surv. 131, 1878–79.
	Mataura Plant-beds, Southland	Rep. N.Z. Geol. Surv. 39, 1879–80.
	Discovery of Chalk near Oxford, Ashley County	Rep. N.Z. Geol. Surv. 49, 1879–80.
	On the Trelissick Basin, Selwyn County	Rep. N.Z. Geol. Surv. 53, 1879–80.
	Curiosity-shop, Rakaia River, Canterbury: Notes to accompany a Collection of Fossils from that Locality	Rep. N.Z. Geol. Surv. 75, 1879–80.
	On the Older Sedimentary Rocks of Ashley and Amuri Counties	Rep. N.Z. Geol. Surv. 83, 1879–80.
	On the Motunau District, Ashley County	Rep. N.Z. Geol. Surv. 108, 1879–80.
	District West and North of Lake Wakatipu	Rep. N.Z. Geol. Surv. 118, 1879–80.
	Coal-discoveries at Shakespeare Bay, near Picton	Rep. N.Z. Geol. Surv. 147, 1879–80.
	On the Genus *Rhynchonella* ..	Trans. xiii. 396.
	Geology of the Waitaki Valley and Part of Vincent and Lake Counties	Rep. N.Z. Geol. Surv. 56, 1881.
	On the Younger Deposits of the Wharekuri Basin and the Lower Waitaki Valley	Rep. N.Z. Geol. Surv. 98, 1881.

Author.	Title.	Name of Publication.
McKay, A. ..	Coal - bearing Deposits near Shakespeare Bay, Picton	Rep. N.Z. Geol. Surv. 106, 1881.
	On the Caswell Sound Marble ..	Rep. N.Z. Geol. Surv. 115, 1881.
	On a Deposit of Moa-bones near Motunau, North Canterbury	Rep. N.Z. Geol. Surv. 74, 1882.
	On the Antimony Lodes of the Carrick Range, Vincent County, Otago	Rep. N.Z. Geol. Surv. 80, 1882.
	On Antimony Lode and Quartz Reef at Langdon's Hill, Grey County	Rep. N.Z. Geol. Surv. 83, 1882.
	On the Albion Gold-mining Company, Hutt County	Rep. N.Z. Geol. Surv. 85, 1882.
	On an Antimony Lode at Reefton, Inangahua County	Rep. N.Z. Geol. Surv. 88, 1882.
	On the Geology of the Reefton District	Rep. N.Z. Geol. Surv. 91, 1882.
	On the Origin of the Old Lake-basins of Otago (abstract)	Trans. xvi. 550; Rep. N.Z. Geol. Surv. 76, 1883–84.
	On the Igneous Rocks of the East Coast of Otago (abstract)	Trans. xvi. 547.
	Otago North-east District ..	Rep. N.Z. Geol. Surv. 45, 1883–84.
	Igneous Rocks of East Wellington	Rep. N.Z. Geol. Surv. 71, 1883–84.
	Otago Lake-basins	Rep. N.Z. Geol. Surv. 76, 1883–84.
	Otago: Clark's Quartz Drifts ..	Rep. N.Z. Geol. Surv. 91, 1883-84.
	Kawakawa Coal-mine ..	Rep. N.Z. Geol. Surv. 95, 1883–84.
	Serpentinous Dykes at Wade ..	Rep. N.Z. Geol. Surv. 99, 1883–84.
	Auckland and Mahurangi Section	Rep. N.Z. Geol. Surv. 101, 1883–84.
	Whangarei-Hokianga Coalfield	Rep. N.Z. Geol. Surv. 110, 1883–84.
	Terawhiti Goldfield	Rep. N.Z. Geol. Surv. 135, 1883–84.
	Kawhia District	Rep. N.Z. Geo. Surv. 140, 1883–84.
	On the Age of the Napier Limestones	Trans. xviii. 367.
	Kaitangata Coalfield	Rep. N.Z. Geol. Surv. 1, 1885.
	Copper-bearing Rocks in the Malvern Hills	Rep. N.Z. Geol. Surv. 5, 1885.
	Iron-ore near Kawakawa ..	Rep. N.Z. Geol. Surv. 9, 1885.
	Antimony Lodes at Endeavour Inlet	Rep. N.Z. Geol. Surv. 10, 1885.
	Kaikoura Mountains	Rep. N.Z. Geol. Surv. 27, 1885.

Author.	Title.	Name of Publication.
McKay, A. ..	Scinde Island and Hawke's Bay District	Rep. N.Z. Geol. Surv. 185, 1885.
	Cabbage Bay, Cape Colville Peninsula	Rep. N.Z. Geol. Surv. 192, 1885.
	The Waihao Greensands and their Relation to the Ototara Limestone	Trans. xix. 434.
	On the Younger Secondary and Tertiary Formations of Eastern Otago, Moeraki, and Waikouaiti	Rep. N.Z. Geol. Surv. 1, 1886–87.
	On the Grey Marl and Weka Pass Stone in Kaikoura Peninsula and at Amuri Bluff	Rep. N.Z. Geol. Surv. 74, 1886–87.
	On the Junction of the Amuri Limestone and Weka Pass Stone, Weka Pass, North Canterbury	Rep. N.Z. Geol. Surv. 78, 1886–87.
	On the Identity and Geological Position of the Greensands of the Waihao Forks, Waihao Valley, South Canterbury	Rep. N.Z. Geol. Surv. 91, 1886–87.
	On the Mokihinui Coalfield ..	Rep. N.Z. Geol. Surv. 161, 1886–87.
	On the Geology of East Auckland and the Northern District of Hawke's Bay	Rep. N.Z. Geol. Surv. 182, 1886–87.
	On the Geology of the Malvern Hills, Canterbury	Rep. N.Z. Geol. Surv. 230, 1886–87.
	On the Geology of the Coastline, Moeraki Peninsula to Kakanui and North-east Otago	Rep. N.Z. Geol. Surv. 233, 1886–87.
	On Mineral Deposits in the Tararua and Ruahine Mountains	Rep. N.Z. Geol. Surv. 1, 1887–88.
	On the Copper-ore at Maharahara, near Woodville	Rep. N.Z. Geol. Surv. 6, 1887–88.
	On the Coal Outcrops in the Wairoa Valley and Hunua Range, near Drury, Auckland	Rep. N.Z. Geol. Surv. 16, 1887–88.
	On certain Calcareous Rocks occurring near Eketahuna, Wairarapa North	Rep. N.Z. Geol. Surv. 18, 1887–88.
	On the Discovery of Metalliferous Rocks in the Patua Range, Taranaki	Rep. N.Z. Geol. Surv. 35, 1887–88.
	On the Geology of the Northern District of Auckland	Rep. N.Z. Geol. Surv. 37, 1887–88.
	On the Tauherenikau and Waiohine Valleys, Tararua Ranges	Rep. N.Z. Geol. Surv. 58, 1887–88.
	Preliminary Report on the Earthquake of September, 1888, in the Amuri and Marlborough Districts of the South Island	Rep. N.Z. Geol. Surv. 1, 1888–89; Bulletin of N.Z. Geol. Surv. 1888, No. 1.
	Mahakipawa Goldfields ..	Rep. N.Z. Geol. Surv. 36, 1888–89.

Author.	Title.	Name of Publication.
McKay, A. ..	The Puponga and Pakawau Coalfields, Collingwood County	N.Z. Mines Record, iv. 74, 186.
	Stewart Island Tin	Rep. N.Z. Geol. Surv. 74, 1888–89.
	Marlborough and Amuri Districts	Rep. N.Z. Geol. Surv. 85, 1888–89.
	On a Deposit of Diatomaceous Earth at Pakaraka, Bay of Islands	Trans. xxiii. 375.
	On Marlborough and South-east Nelson (Faults)	Rep. N.Z. Geol. Surv. 1, 1890–91.
	On the Maungahao Coal ..	Rep. N.Z. Geol. Surv. 28, 1890–91.
	On the Waimea Coal ..	Rep. N.Z. Geol. Surv. 1890–91.
	On the Old Phœnix Mine, Terawhiti	Rep. N.Z. Geol. Surv. 35, 1890–91.
	On the Limestone and Marble Deposits of Pikikiruna, Nelson	Rep. N.Z. Geol. Surv. 38, 1890–91.
	On the Prospects of Coal near Otakia, Otago	Rep. NZ. Geol. Surv. 43, 1890–91.
	On Coal near Rowley's Farm, near Shag Point	Rep. N.Z. Geol. Surv. 45, 1890–91.
	On the Quartz Reefs of Nenthorn, Otago	Rep. N.Z. Geol. Surv. 50, 1890–91.
	On Antimony on Barewood Run, Taieri River	Rep. N.Z. Geol. Surv. 54, 1890–91.
	On the Puhipuhi Silver-field, Auckland	Rep. N.Z. Geol. Surv. 55, 1890–91.
	On Prospects of Coal at Pakaraka, Bay of Islands	Rep. N.Z. Geol. Surv. 59, 1890–91.
	On the Geology of the Lower Waikaka Valley and Auriferous Drift at Switzers	Rep. N.Z. Geol. Surv. 63, 1890–91.
	On the District surrounding Whangaroa Harbour, Mongonui County	Rep. N.Z. Geol. Surv. 65, 1890–91.
	On the Lignite of Cooper's Beach, Mongonui	Rep. N.Z. Geol. Surv. 72, 1890–91.
	On the New Cardiff Coal Property, Mokihinui, between Buller and Mokihinui Rivers	Rep. N.Z. Geol. Surv. 76, 1890–91.
	On the Mokihinui Coal Company's Property, Coal Creek	Rep. N.Z. Geol. Surv. 86, 1890–91.
	On the Middle Waipara and Weka Pass Districts	Rep. N.Z. Geol. Surv. 97, 1890–91.
	On a Diatom Deposit near Pakaraka, Bay of Islands	Trans. xxv. 375.
	Geological Exploration of the Northern Part of Westland. Appendix: List of Rocks and Minerals	Rep. Mines Dept. C.–3, 132, 1893.
	Report on the Geology of the South-west Part of Nelson and the Northern Part of the Westland District	Rep. Mines Dept. C.–3, 161, 1895.

Author.	Title.	Name of Publication.
McKay, A. ..	On the Geology of the Cape Colville Peninsula	Rep. Mines Dept. 1899; N.Z. Mines Record, i. 278.
	Report on the Older Auriferous Drifts of Central Otago	Republished, 1897.
	Report on the Auriferous Rocks of the Western Slopes of the Victoria Mountains	N.Z. Mines Record, i. 303.
	Notes on the Auriferous Ironsands of New Zealand	N.Z. Mines Record, i. 395, 446.
	Report on the Geology of the Thames and the Southern Goldfields of the Cape Colville Peninsula	N.Z. Mines Record, i. 527.
	The Gumtown Goldfield ..	N.Z. Mines Record, iii. 265.
	The Copper Lode in the Ruahine Range, near Norsewood, Hawke's Bay	N.Z. Mines Record, iv. 415.
Mair, Major W. G.	Notes on the Eruption of Tarawera Mountain and Rotomahana, 10th June, 1886, as seen from Taheke, Lake Rotoiti	Trans. xix. 372.
Malfroy, Camille..	The Geyser Action of Rotorua ..	N.Z. Jrnl. Sci. iii. 203; Trans. xxiv. 579.
Mannering, G. ..	On the Murchison Glacier ..	Trans. xxiii. 355.
Mantell, W. G. A.	Motion *in re* Skeleton found by Dr. Haast (see Trans. N.Z. Inst. vii.)	Order Paper, Legislative Council, Oct. 19, 1875; Nature, Jan. 6, 196, 1876.
Marchbanks, J. ..	On the Artesian Wells at Longburn	Trans. xxxi. 551.
Marshall, P. ..	Tridymite Trachyte of Lyttelton	" xxvi. 368.
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Mueller, Gerhard	Report on West Coast between Cascade Plateau and Jackson's River on the North and Lake McKerrow and Hollyford Valley on the South	Rep. N.Z. Survey Dept. 73, 1883–84.
Murdoch, R. ..	Description of some New Species of Pliocene Mollusca from the Wanganui District, with Notes on other Described Species	Trans. xxxii. 216.

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Mulgan, E. K. ..	On the Volcanic Grits and Ash-beds in the Waitemata Series	Trans. xxxiii. 414.
Park, James ..	On the Geology of the Auckland Provincial District	Rep. N.Z. Geol. Surv. 136, 1885.
	Ascent of Mount Franklin, Nelson	Trans. xvii. 350.
	Kakahu District	Rep. N.Z. Geol. Surv. 170, 1885.
	Older Fossiliferous Rocks in Nelson	Rep. N.Z. Geol. Surv. 188, 1885.
	On the Geology of the Western Part of Wellington Provincial District and Part of Taranaki	Rep. N.Z. Geol. Surv. 24, 1886–87.
	Kaipara and Wade Districts ..	Rep. N.Z. Geol. Surv. 219, 1886–87.
	On the Upper Wanganui and King-country	Rep. N.Z. Geol. Surv. 167, 1886–87.
	On the Gold-discovery at Waimarino	Rep. N.Z. Geol. Surv. 155, 1886–87.
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	On the District between the Dart and Big Bay	Rep. N.Z. Geol. Surv. 121, 1886–87.
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	On the Wangapeka Silver-mine	Rep. N.Z. Geol. Surv. 90, 1887–88.
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	On the Perseverance Gold-mine, Terawhiti Goldfield	Rep. N.Z. Geol. Surv. 69, 1886–87.

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Park, James ..	On the New Goldfield at Terawhiti	Rep. N.Z. Geol. Surv. 69, 1887–88.
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	Antimony Lode, Alexandra, Otago	Rep. N.Z. Geol. Surv. 33, 1888–89.
	Portobello Reef, Otago ..	Rep. N.Z. Geol. Surv. 34, 1888–89.
	Red Hill Mine, Nelson ..	Rep. N.Z. Geol. Surv. 45, 1888–89.
	West Wanganui, Nelson ..	Rep. N.Z. Geol. Surv. 49, 1888–89; N.Z. Mines Record, iv. 78.
	Antimony-mine, Endeavour Inlet	Rep. N.Z. Geol. Surv. 60, 1888–89.
	Terawhiti Mine, Wellington ..	Rep. N.Z. Geol. Surv. 63, 1888–89.
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	Baton Goldfield, Nelson ..	Rep. N.Z. Geol. Surv. 69, 1888–89.
	Quartz Ranges, Nelson ..	Rep. N.Z. Geol. Surv. 67, 1888–89.
	Fluor Spar, Baton River, Nelson	Rep. N.Z. Geol. Surv. 73, 1888–89.
	Collingwood County	Rep. N.Z. Geol. Surv. 191, 1888–89.
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Park, James ..	The Geology, Resources, and Future Prospects of the Thames Goldfield	Rep. Mines Dept. C.-3, 29, 1894.
	Notes on the Geology of the Kuaotunu Goldfields	Trans. xxvi. 360.
	On the Occurrence of some Rare Minerals in New Zealand	Trans. xxvi. 365; Aust. Assoc. Adv. Sci. iii. 150.
	Notes on the Rhyolites of the Hauraki Goldfields, New Zealand	Quart. Jrnl. Geol. Soc. 55, 1899.
	Notes on some Andesites from Thames Goldfields	Trans. xxxiv. 435.
	On the Secular Movements of the New Zealand Coast-line	" xxxiv. 441.
	Notes on some Glacier Moraines in the Leith Valley	" xxxiv. 444.
	The Geology of Mines and Minerals	Dunedin (sep. pub.), 1902; and in Otago Witness.
	The Geology and Veins of the Hauraki Goldfields, New Zealand. Maps and Sections	N.Z. Inst. Mining Eng. 1897; Auckland; also N.Z. Mines Record, i. 168.
	Notes on the Coalfields of New Zealand	Proc. Inst. Mining and Metall. viii. 146; N.Z. Mines Record, iii. 350.
	Cyaniding in New Zealand ..	Trans. Am. Inst. Mining Eng. xxix. 666; N.Z. Mines Record, iii. 275.
	Notes on Geological Examinations of Hauraki Goldfields	N.Z. Mines Record, iii. 376.
Owen, Sir Richard	On Reptilian Fossils discovered by Mr. Cockburn-Hood in New Zealand	Trans. Brit. Assoc. 122, 1861.
	On *Plesiosaurus crassicostatus* and *P. hoodii*	Geol. Mag. vii. 49.
Peppercorne, Fr. S.	Geological and Topographical Sketches of the Province of New Ulster, Auckland	1852.
Perkins, A. C. ..	Notes on Gold-dredging in New Zealand	N.Z. Mines Record, iv. 153.
Petermann, A., and Hochstetter, F. von	The Geology of New Zealand ..	Auckland, 1864.
Pharazyn, R. ..	Remarks on the Coast-line between Kai Iwi and Waitotara, on the West Coast of the Province of Wellington	Trans. ii. 158.
Phillips, Coleman	The Volcanoes of the Pacific ..	" xxxi. 510.
Piper, J. W. H. ..	Notes on Gold-dredging in New Zealand and New South Wales	Trans. xxxii. 188; N.Z. Mines Record, iii. 429.
Polack, J. Samuel	New Zealand	Vol. i. chap. x. (Mineralogy and Geology).
Pond, J. A. ..	Note on a Salt Spring near Hokianga	Trans. xi. 512.

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Pond, J. A. ..	On the Occurrence of Platinum in Quartz Lodes at the Thames Goldfields	Trans. xv. 419.
Pond, J. A., and Smith, S. Percy	Observations on the Eruption of Mount Tarawera, Bay of Plenty, New Zealand, 10th June, 1886	„ xix. 342.
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Pyke, Vincent ..	Report on the Progress, Condition, and Prospects of the Goldfields of Otago	Otago Prov. Gov. Gaz. 219, 1862.
Rickard, T. A. ..	On the Goldfields of Otago .. Alluvial Mining in Otago ..	Trans. Am. Inst. Mining Eng. xxi. 411, 442.
Rochfort ..	Report on the Coalfields of Nelson	Nelson Gazette, April 11, No. 21, 1863.
Rowe, W. E. ..	On the Antimony-mine at Hindon, Taieri County	Rep. N.Z. Geol. Surv. 153, 1879–80.
	On the Stony Creek Antimony-mine, Waipori, Tuapeka County	Rep. N.Z. Geol. Surv. 155, 1879–80.
	On Waitahuna Copper Lode, near Waipori, Tuapeka County	Rep. N.Z. Geol. Surv. 156, 1879–80.
	On the Mount Solitary Copper Lode, Dusky Sound, Fiord County	Rep. N.Z. Geol. Surv. 150, 1879–80.
	Further Report on Mount Solitary Copper Lode, Dusky Sound, Fiord County, and Malcolm's Lode	Rep. N.Z. Geol. Surv. 159, 1879–80.
Russell J. C. ..	Notes on the Ancient Glaciers of New Zealand (reprinted from Ann. Lyceum Nat. Hist. N.Y. 1876)	Nature, xvi. 100.
Russell, J. N. ..	Letters from J. N. Russell and Co., of Sydney, reporting the Results of Experiments with Kawakawa Coal	Auck. Prov. Council, Sess. xviii. 1865.
Rutley, Frank ..	Additional Notes on some Eruptive Rocks from New Zealand	Quart. Jrnl. Geol. Soc. 56, xxvii.
Schiff, F ..	Les Mines D'Or de la Nouvelle-Zelande	Le Génie Civil, iii. 83, 1899; N.Z. Mines Record (review).
Shrewsbury, Hugh	The Auckland Volcanoes ..	Trans xxiv. 366.
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	On Gold: its Formation in our Reefs, and Notes of some Newly Discovered Reactions	Aust. Assoc. Adv. Sci. i. 155.
	Note on the Processes in use in the Thames Mining District for the Extraction of Gold from the Matrix	Rep. N.Z. Geol. Surv. 71, 1870–71.

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	The Eruption of Tarawera: a Report to the Surveyor-General	1886.
	Geological Notes on the Kermadec Group	Trans. xx. 333.
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Taylor, Rev. Rich.	The Age of New Zealand ..	Auckland, 1865.
	"Te Ika-a-Maui," chap. xxvi...	1855 and 1870.
Tenison-Woods, Rev. J. E.	Corals and *Bryozoa* of the Neozoic Period in New Zealand	Palæont. of N.Z. pt. iv. Wellington, 1880.
Thomas, A. P. W.	Report on the Eruption of Tarawera, with Maps	1888.
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Travers, W. T. L.	On the Sand-worn Stones of Evans Bay, Wellington	Trans. ii. 247.
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Tunny, J. M. ..	The Coals and Coalfields of the Province of Auckland	Trans. viii. 387.
Ulrich, G. H. F. ..	Longwood and Merivale Goldfields	Parl. Paper C.-7, Sess. I. 1887.
	Notice of the Discovery of a Peculiar Alloy of Iron and Nickel in New Zealand Rocks	Quart. Jrnl. Geol. Soc. xliii. 8.
	On the Dykes of Bendigo Reefs, Australia	Trans. Am. Inst. Mining Eng. xxii. 756.
	On the Discovery, Mode of Occurrence, and Distribution of the Nickel-iron Alloy Awaruite on the West Coast of the South Island of New Zealand	Quart. Jrnl. Geol. Soc. xlvi. 619; N.Z. Jrnl. Sci. iii. 60.
	Note on some Mineral Occurrences at Dusky Sound, West Coast of New Zealand	N.Z. Jrnl. Sci. ii. 306.
	On the Occurrence of Nepheline-bearing Rocks in New Zealand	Aust. Assoc. Adv. Sci. iii. 127.
	Mount Benger Mining District	Rep. N.Z. Geol. Surv. 12, 1883-84.
Ulrich, G. H. F., and Hutton, F.W.	Report on Geology and Goldfields of Otago	Dunedin, 1875.
Van Beneden, P. J.	On a New Fossil Bird—*Anas finschi*—from Earnscleugh Cave	Trans. ix. 599.
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Wells, W. ..	On the Drift-beds of Wakapuaka and Port Hills, with Remarks on the Boulder Bank Formation	Trans. xvii. 344.
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NEW ZEALAND INSTITUTE

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THIRTY-FOURTH ANNUAL REPORT.

MEETINGS of the Board were held on the 26th November, 1901; 17th January, 13th February, 16th May, and 15th August, 1902.

Messrs. Travers, Joynt, and Young retired from the Board in compliance with the Act, and were renominated by His Excellency the Governor. The following gentlemen were elected by the Incorporated Societies as Governors of the New Zealand Institute: Hon. C. C. Bowen, Mr. S. Percy Smith, and Mr. Martin Chapman.

The members now on the roll are—Honorary members, 29; Auckland Institute, 162; Hawke's Bay Philosophical Institute, 64; Wellington Philosophical Society, 144; Philosophical Institute of Canterbury, 69; Otago Institute, 117; Nelson Institute, 50; Wesland Institute, 54: making a total of 689.

The volumes of Transactions now on hand are—Vol. I. (second edition), 220; Vol. V., 6; Vol. VI., 10; Vol. VII., 95; Vol. IX., 93; Vol. X., 120; Vol. XI., 20; Vol. XII., 25; Vol. XIII., 25; Vol. XIV., 48; Vol. XV., 155; Vol. XVI., 160; Vol. XVII., 160; Vol. XVIII., 125; Vol. XIX., 150; Vol. XX., 154; Vol. XXI., 85; Vol. XXII., 87; Vol. XXIII., 160; Vol. XXIV., 165; Vol. XXV., 160; Vol. XXVI., 170; Vol. XXVII., 168; Vol. XXVIII., 173; Vol. XXIX., 295; Vol. XXX., 347; Vol. XXXI., 396; Vol. XXXII., 396; Vol. XXXIII., 400; Vol. XXXIV., not yet fully distributed.

The volume just published (XXXIV.) contains fifty-four articles, and also addresses and abstracts which appear in the Proceedings; it consists of 645 pages and forty-two plates. The following is a comparison of the contents of Vol. XXXIV. with those of Vol. XXXIII.:—

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The cost of printing Vol. XXXIII. was £384 14s. for 626 pages and twenty-three plates, and that for the present volume (XXXIV.) £452 2s. 6d. for 645 pages and forty-two plates. The present volume was entirely produced by the Government Printing Office.

From the Honorary Treasurer's statement of accounts it appears that the amount received for the year was £1,214 4s., including the balance carried forward, and the expenditure £806 1s. 1d., leaving a balance in hand of £408 2s. 11d.

The publication of "Maori Art" has been completed, and bound volumes may now be purchased at the price of £4 4s.

Museum.

There have been 140 entries as additions to the Museum since last report, a list of which will be published in due course. The collections have been thoroughly cleaned, and many changes have been made to improve their arrangement.

Library.—This is being continually added to, and every endeavour has been made to keep it scientifically up to date.

Meteorological.

The returns of the principal stations for 1901 have been supplied as usual to the Registrar-General to be included in his annual statistics, and the monthly rainfall returns from 174 stations have been regularly supplied to the *Gazette*. The monthly return for vital statistics has been supplied, and the daily weather exchange, by telegraph, is continued between this colony and Australia.

Colonial Time-ball Observatory.

Mr. Thomas King, the officer in charge, reports that the instruments in the Observatory are in complete order, and details the services which have been rendered in supplying true mean time to the antarctic exploring-ship "Discovery" and H.M.S. "Penguin," the latter being engaged in surveying the N.E. coast of New Zealand. Full details of these exchanges of time will be published in due course.

The balance-sheet, duly certified, is appended, and the schedules and correspondence will be published with the report in the usual pamphlet form.

JAMES HECTOR, Manager.

Approved.—THOMAS MASON, Chairman.—Wellington, 15th August, 1902.

NEW ZEALAND INSTITUTE ACCOUNTS FOR 1901–2.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
Balance from last year	538	16	4	Printing Vol. XXXIV.	452	2	6
Vote for 1901–2 ..	500	0	0	Expenses of library ..	20	0	0
Contribution from Wellington Philosophical Society	13	2	6	Expenses, "Maori Art"	258	15	10
Sale of "Maori Art" ..	162	5	2	Postage, foreign volumes	2	18	0
				Miscellaneous items ..	72	4	9
				Balance	408	2	11
	£1,214	4	0		£1,214	4	0

Examined and found correct.

WM. THOS. LOCKE TRAVERS,
Treasurer.

15th August, 1902.

PROCEEDINGS

WELLINGTON PHILOSOPHICAL SOCIETY.

First Meeting: *5th August, 1902.*

Mr. W. T. L. Travers, F.L.S., President, in the chair.

Inaugural address by the President on "The Bird as the Labourer of Man." (*Transactions*, p. 1.)

A discussion followed, in which Messrs. Hustwick, Harding, T. W. Kirk, Hogben, Tregear, Chapman, and Sir James Hector took part, the general opinion expressed being antagonistic to the provisions of the Small Birds Nuisance Bill now before Parliament.

Sir James Hector exhibited a number of insectivorous birds, and described the different species and their habits of life; also specimens of the male and female of the eider duck, with the following note:—

The Colonial Museum has for some years possessed an eider duck (*Somateria mollissima*) in good plumage, and has recently received, through the kind efforts of Sir Walter Buller, a drake of the same bird, so that I am able to present a pair of this most interesting species. Sir Walter Buller writes as follows: "I have much pleasure in presenting to the Colonial Museum a very fine adult male specimen of the eider duck (or dunter goose, as it is called in Scotland), which I trust will be an acceptable addition to the collection of birds. The eider duck (*Somateria mollissima*) is very abundant in the arctic regions of both continents, also on the coasts of Norway, Sweden, and Labrador, where, as is well known, the down, self-plucked from its body for nesting purposes, is an important article of commerce. It is plentiful on the northern coasts of Scotland, and occurs, in diminished numbers, some degrees further southward, being not unfrequent in the Hebrides, Shetland, and Orkney Islands; but here, although they have many nesting-places, they are not sufficiently numerous to be of any importance from an economica point of view. Occasionally individuals stray further south, and are in much request as rare visitants. The specimen sent was obtained at Brechen, Scotland, in March, 1902. I purchased it in the flesh, and had it carefully skinned and prepared by Mr. Walter Burton, of Wardour Street."

Opossums presented to the Colonial Museum by Mr. Smith, of Petone, were exhibited.

In remarking on the acquisition, Sir James Hector stated that the real opossum was peculiar to the Continent of America, and was not known anywhere else. The proper name of the exhibits should be

"phalanger," and "opossum-rugs" should be called "phalanger-rugs." The phalanger was common all over Australia and Tasmania, and had been introduced and was becoming common in New Zealand. It was a most destructive animal to fruit-trees.

Mr. J. J. Walker, of H.M.S. "Ringarooma" mentioned that at Kawau, "Sir George Grey's island," it was almost impossible to grow fruit owing to the number of phalangers.

A fine specimen of carunculated shag caught on White Rock was also exhibited. Two more of the birds had been prepared for presentation by Lord Ranfurly to the British Museum.

It was stated that there was on the island a little colony of about twenty pairs of the birds, and it was noted as strange that they should be pairing at the time the "Ringarooma" visited the spot (8th July). That was in the depth of winter.

Papers.—1. "Notes on Whitebait," by A. J. MacKenzie; communicated by Sir J. Hector. (*Transactions*, p. 309.)

2. "Notes on Whitebait," by E. Gibson; communicated by Sir J. Hector. (*Transactions*, p. 311.)

3. "On *Galaxias* (Whitebait)," by Sir James Hector. (*Transactions*, p. 312.)

Before concluding the meeting the President made a few remarks on the Wairaki clay which he had lately found.

He stated that a quantity of it was handed over to Mr. P. Hutson, who manufactured from it a bottle and jar, which Mr. Travers described as "the equal of anything turned out by Doulton." The clay arose chiefly from a decomposition of pumice, and was nearly pure white and of remarkably good texture.

Mr. Hutson stated that if he could get the clay at a reasonable price he would use it in preference to the kaolin clay which he had now to import from Europe.

Second Meeting: *18th November, 1902.*

Mr. W. T. L. Travers, F.L.S., President, in the chair.

New Member.—Mr. D. A. S. Cowper, Wellington.

Mr. Martin Chapman was again nominated to represent the Society on the Board of the New Zealand Institute.

Papers.—1. "On the Construction of a Table of Natural Sines," by C. E. Adams, B.Sc. (*Transactions*, p. 408.)

2. "On *Charagia virescens*," by A. Quail, F.E.S. (*Transactions*, p. 249.)

3. "On Hybrid Ferns," by H. C. Field. (*Transactions*, p. 372.)

Messrs. Travers and Hustwick entirely disagreed with the theory propounded in this paper, and were of opinion that hybridization of ferns was not possible, the specimens under notice being mere varieties.

4. "On some New Species of *Lepidoptera* (Moths) from Southland," by A. Philpott. (*Transactions*, p. 246.)

5. "On some New Species of *Macro-lepidoptera*," by G. V. Hudson, F.E.S. (*Transactions*, p. 243.)

6. "On Adjustment of Triangulation by Least Squares," by C. E. Adams, B.Sc. (*Transactions*, p. 201.)

7. "Notes on a New Method of Determination of Minerals by their Refringence," by C. E. Adams, B.Sc.

Mr. T. H. Hustwick informed the meeting that he had recently received for examination four samples of "infusorial earth" from different parts of the colony—from Dunedin, Auckland, Taranaki, and Oamaru.

It was intended, he said, if practicable, to use the infusorial earth in connection with a patent for cheap and effective lighting. A chemical examination showed that the four samples were all pure infusorial earth, nearly as good as the kieselguhr, which was worked in Germany and elsewhere on the Continent for the manufacture of dynamite. The sample from Dunedin was very pure, and that from Auckland was fair, but the other two showed only a small proportion of siliceous remains. The two latter also contained a considerable quantity of carbonate of lime, on account of which it was considered unsuitable for the purposes of an absorptive. Mr. Hustwick assured the President that the earth could be obtained in quantity in New Zealand.

Third Meeting: *16th December, 1902.*

Mr. W. T. L. Travers, F.L.S., President, in the chair.

Papers.—1. "On the Anatomy of *Paryphanta busbyi*, Gray," by R. Murdoch. (*Transactions*, p. 258.)

2. "On the Use of the Standard Functions in Interpolation," by E. G. Brown. (*Transactions*, p. 420.)

Annual Meeting: *18th March, 1903.*

Mr. W. T. L. Travers, F.L.S., President, in the chair.

Abstract of Annual Report.

During the year three meetings were held, at which nineteen papers were read.

The balance-sheet shows the receipts for the year to be £184 16s. 2d., and the expenditure £95 18s. 8d., leaving a balance in hand of £88 17s. 6d.

The Research Fund, a fixed deposit in the bank, now amounts to £37 13s., which increases the credit balance to £126 10s. 6d.

Election of Officers for 1903.—*President*—Professor Easterfield; *Vice-presidents*—Sir J. Hector, F.R.S., and G. Hogben, M.A.; *Council*—E. Tregear, F.R.G.S., M. Chapman, R. C. Harding, G. V. Hudson, F.E.S., H. N. McLeod, H. B. Kirk, M.A., and C. E. Adams, B.Sc.; *Secretary and Treasurer*—A. H. Gore; *Auditor*—T. King.

New Member.—R. I. Kingsley, Nelson.

Papers.—1. "On New Zealand Mean Time and on the Longitude of the Colonial Observatory, Wellington; with a Note on the Universal-time Question," by Thomas King. (*Transactions*, p. 428.)

This paper elicited an interesting discussion, in which Messrs. Martin Chapman, Adams, Hustwick, and Sir James Hector took part.

2. "Notes on the Habits of a Spider (*Porrhothele antipodiana*) and a Fly (*Salius monachus*)," by A. Quail, F.E.S. (*Transactions*, p. 256.)

3. "A Contribution to the Chemistry of Colophony," by Professor Easterfield and G. Bagley. (*Transactions*, p. 476.)

This paper, which was illustrated by a splendid series of exhibits, was listened to with great attention.

4. "On the Molecular Complexity of Fatty Acids and their Derivatives in Phenol Solution," by P. W. Robertson. (*Transactions*, p. 452.)

5. "The Exhibition of a Maximum or Minimum in the Properties of certain Series of Organic Compounds," by P. W. Robertson. (*Transactions*, p. 465.)

6. "A List of Plants growing at 'The Gums,' Taita," by T. Mason. (*Transactions*, p. 374.)

7. "List of Papers on the Geology of New Zealand," by A. Hamilton. (*Transactions*, p. 489.)

The retiring President (Mr. W. T. L. Travers) gave a short address.

He said that his term of office had been an exceedingly pleasant one, and he heartily congratulated the Society on their very wise selection of Professor Easterfield as President for the ensuing year. He also congratulated the members on the good work which had been done during the past year, and thanked them for the assistance given him in carrying out the duties of his office. He referred to the paper read by him when he assumed the presidency, relating to the mistaken crusade against small birds. He said that his contention had received the amplest confirmation in the late bountiful harvest in the South Island. Never had the birds been more numerous or the complaints of the "pest" more bitter, yet the yield of grain was absolutely without precedent, and to the birds who had destroyed the natural enemies of the corn the credit was due. But the agriculturists had again justified Virgil's old complaint of the "greedy husbandman" who grudged his best friends the well-earned toll they exacted for their services.

AUCKLAND INSTITUTE.

First Meeting: *9th June, 1902.*

Dr. E. Roberton, President, in the chair.

New Members.—E. Clark, D. Jones.

The President delivered the anniversary address, taking as his subject "Malaria and Mosquitos." (*Transactions*, p. 225.)

Second Meeting: *7th July, 1902.*

Dr. E. Roberton, President, in the chair.

Papers.—1. "Notes on the Pollination of *Rhabdothamnus*," by D. Petrie, M.A. (*Transactions*, p. 321.)

2. "A Visit to Tahiti and the Society Islands," by Josiah Martin.

This paper was illustrated by numerous lime-light transparencies prepared from photographs obtained by the author.

Third Meeting: *4th August, 1902.*

Dr. E. Roberton, President, in the chair.

Papers.—1. "On the Maori method of catching certain Fish in the Piako River," by Captain Gilbert Mair, N.Z.C. (*Transactions*, p. 319.)

2. "Chips from an Ancient Maori Workshop," by Captain Gilbert Mair. (*Transactions*, p. 240.)

3. "On the Cultivation and Treatment of the Kumara by the Primitive Maori," by Archdeacon Walsh. (*Transactions*, p. 12.)

Fourth Meeting: *18th August, 1902.*

Dr. E. Roberton, President, in the chair.

Papers.—1. "On the Flood of Gold," by Professor H. W. Segar. (*Transactions*, p. 122.)

2. "Remarks on the Trade and Public Debt of New Zealand," by Professor H. W. Segar. (*Transactions*, p. 117.)

FIFTH MEETING: *1st September, 1902.*

Dr. E. Roberton, President, in the chair.

The Rev. W. Gray Dixon, M.A., gave a popular lecture on "Japanese Mediævalism."

SIXTH MEETING: *15th September, 1902.*

Dr. E. Roberton, President, in the chair.

Professor C. W. Egerton gave a popular lecture on "Tennyson."

SEVENTH MEETING: *6th October, 1902.*

Dr. E. Roberton, President, in the chair.

New Members.—C. Bagley, M. F. Carey, T. Gilbert, R. H. Makgill, M.D.

Papers.—1. "The Food-products of Tuhoe-land," by Elsdon Best. (*Transactions*, p. 45.)

2. "More Foot-tracks of Captain Cook," by H. D. M. Haszard. (*Transactions*, p. 24.)

3. "Universal Equal Suffrage," by E. E. Vaile.

EIGHTH MEETING: *20th October, 1902.*

Dr. E. Roberton, President, in the chair.

Dr. R. H. Makgill gave a popular lecture on "Nature's Efforts at Sanitation." (*Transactions*, p. 139.)

ANNUAL MEETING: *23rd February, 1903.*

Dr. E. Roberton, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

The Council submits the thirty-fifth annual report, dealing with the financial and general condition of the Institute and the progress it has made during the past year.

Ten new members have been elected during the year. The names withdrawn from the roll have been eight—three from death and five from resignation. The total number on the roll at the present time is 163.

The Council have received under the will of the late Mrs. Mackechnie a bequest of £2,500. Of this the sum of £2,000 is to be invested by the trustees, and the annual income regularly devoted to the purchase of scientific books for the library. The remaining amount of £500 is to be expended by the executor under the will in such additions to the Museum as he in his sole discretion shall consider advisable.

The balance-sheets show that the total revenue of the Working Account, omitting the balance of £76 6s. 6d. in hand at the commencement of the year, has been £851 14s. 8d., a satisfactory increase on the ordinary income of the previous year, which was £809 8s. 10d. Examining the separate items, it will be seen that the receipts from the invested funds of the Costley Bequest have been £325 13s. 9d., the amount for 1901–2 having been £365 8s. 2d. The Museum endowment has yielded in rents and interest £375 15s. 7d., the sum for the previous year having been £309 10s. The members' subscriptions have amounted to £141 15s., being a gratifying advance on the amount collected during the previous year. The total expenditure has been £868 2s. 8d., leaving a balance of £59 18s. 6d. in the Bank of New Zealand. There is no change of importance with respect to the invested funds of the Institute, the total amount of which is £13,996 6s. 2d., showing an increase of £108 7s. 5d. during the year. Practically the whole of this sum is invested in mortgage on freehold securities or in Government debentures.

The Institute still retains the management of the Little Barrier Island as a reserve for the preservation of the avifauna of New Zealand. The Curator reports that no attempts have been made to interfere with the birds, and that no unauthorised persons have landed upon the island. The Council are satisfied that if a resident guardian is maintained the island will long remain a secure home for a considerable portion of the avifauna of New Zealand.

ELECTION OF OFFICERS FOR 1903.—*President*—Professor A. P. Thomas, F.L.S.; *Vice-presidents*—E. Roberton, M.D., and J. Stewart, M.I.C.E.; *Council*—Professor F. D. Brown, C. Cooper, H. Haines, F.R.C.S., E. V. Miller, T. Peacock, D. Petrie, J. A. Pond, J. Reid, Professor H. W. Segar, Professor H. H. Talbot-Tubbs, J. H. Upton; *Secretary and Curator*—T. F. Cheeseman, F.L.S., F.Z.S.

Paper.—"New Species of New Zealand Grasses," by Professor E. Hackel; communicated by T. F. Cheeseman, F.Z.S (*Transactions*, p. 377.)

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

First Meeting: *7th May, 1902.*

Mr. J. B. Mayne, President, in the chair.

New Members.—Professor T. G. R. Blunt, Messrs. William Lowrie, A. R. Craddock, and James Drummond.

Address.—Captain F. W. Hutton, the retiring President, delivered his address on "Penguins and Petrels," postponed from the annual meeting.

The address was illustrated by a large number of lantern-slides, and a hearty vote of thanks to Captain Hutton was passed at its close.

Second Meeting: *4th June, 1902.*

Mr. J. B. Mayne, President, in the chair.

New Member.—Dr. J. P. Frengley, D.P.H.

Address.—Dr. W. P. Evans delivered an address on "The Production of Colour by Absorption."

The address was illustrated with numerous experiments and lantern-slides.

Third Meeting: *2nd July, 1902.*

Mr. J. B. Mayne, President, in the chair.

Owing to the very inclement weather an address and a paper prepared for the meeting were postponed.

The Secretary laid on the table and made some remarks upon three papers recently published by Professor Dendy.

Fourth Meeting: *6th August, 1902.*

Mr. J. B. Mayne, President, in the chair.

Address.—Dr. C. C. Farr delivered an address on "The Present State of our Knowledge of the Electrical Conditions of the Atmosphere."

The address was illustrated by numerous diagrams and experiments, and was followed by a discussion in which several members took part.

The Secretary laid on the table the volume of the "Transactions of the New Zealand Institute" for 1901, and also copies of the "Prospectus of the Index Faunæ Novæ-Zealandiæ," and explained the action taken by the Institute with regard to the publication of the index.

Fifth Meeting: *3rd September, 1902.*

Mr. J. B. Mayne, President, in the chair.

New Member.—Mr. Henry Scott.

The President welcomed Mr. G. M. Thomson, hon. secretary of the Otago Institute, who was present.

Address.—Mr. F. W. Hilgendorf, M.A., B.Sc., delivered an address on "The Structure and Habits of the New Zealand *Rotifera.*"

The address was illustrated with diagrams and microscopical preparations.

Papers.—1. "Two Spherical Harmonic Relations," by C. Coleridge Farr, D.Sc. (*Transactions*, p. 414.)

2. "List of the New Zealand *Hymenoptera,*" by P. Cameron; communicated by Captain F. W. Hutton. (*Transactions*, p. 290.)

3. "Structure of the Leaf in certain Species of *Coprosma,*" by Miss N. A. R. Greensill, M.A. (*Transactions*, p. 342.)

4. "The Structure of the Stem of some New Zealand Leafless Plants," by Miss A. C. Finlayson, M.A.; communicated by Dr. Charles Chilton. (*Transactions*, p. 360.)

5. "A New Species of *Odontria,*" by Mr. J. H. Lewis, F.E.S.; communicated by Mr. W. W. Smith, F.E.S. (*Transactions*, p. 272.)

Exhibit.—Mr. R. M. Laing exhibited and made remarks upon portion of the trunk of a tree on which some initials had been cut about nine years ago, the initials showing in the interior of the wood as well as on the bark.

Sixth Meeting: *1st October, 1902.*

Mr. J. B. Mayne, President, in the chair.

New Member.—Mr. W. R. Marriner.

Address.—Professor T. G. R. Blunt delivered an address on "The Provençal Troubadours."

Paper.—"*Musci* of the Calcareous Districts of New Zealand, with Descriptions of New Species," by R. Brown. (*Transactions*, p. 323.)

Seventh Meeting: *5th November, 1902.*

Mr. J. B. Mayne, President, in the chair.

Address.—Professor R. J. Scott delivered an address on "The Strength and Elasticity of some Australian and New Zealand Timbers."

At the close of the address, which was illustrated by numerous exhibits and diagrams, the meeting adjourned to the Engineering Laboratory, where Professor Scott gave a demonstration of the method of testing the strength and elasticity of timber by the 50-ton testing-machine.

Eighth Meeting: *26th November, 1902.*

Mr. J. B. Mayne, President, in the chair.

Address.—Dr. C. Coleridge Farr gave an address on "The Interpretation of Earthquake Diagrams." (*Transactions*, p. 415.)

The address was illustrated by various lantern-slides, and the matter was discussed by several of the members.

Papers.—1. "On a Supposed Magnetic Sense of Direction in Bees," by F. W. Hilgendorf, M.A., B.Sc. (*Transactions*, p. 483.)

2. "Short Notes on Various Insects," by F. W. Hilgendorf, M.A., B.Sc. (*Transactions*, p. 264.)

3. "Revised and Expanded List of New Zealand *Rotifera*," by F. W. Hilgendorf, M.A., B.Sc. (*Transactions*, p. 267.)

4. "A New Species of *Psyllidæ*," by G. R. Marriner. (*Transactions*, p. 305.)

5. "Some Recent Changes in the Nomenclature of the New Zealand *Myrsinaceæ*," by L. Cockayne. (*Transactions*, p. 355.)

Exhibit.—The Secretary exhibited a fresh-water Isopod recently found on Ruapuke Island by Mr. H. B. Kirk.

The Isopod belongs to the genus *Phreatoicus*, species of which are known from Australia and from the underground waters of New Zealand, but which had not been previously recorded from the surface waters of New Zealand.

ANNUAL MEETING: *1st April, 1903.*

Mr. J. B. Mayne, President, in the chair.

New Members.—Miss Bing and Mr. J. H. Seager.

ABSTRACT OF ANNUAL REPORT.

Since the last annual meeting eight ordinary meetings have been held, at which twelve papers have been read. These papers may be classified as follows: Zoology, 6; botany, 4; miscellaneous, 2.

At several of the meetings addresses of more popular interest were delivered—viz., "Penguins and Petrels," by Captain F. W. Hutton, F.R.S.; "The Production of Colour by Absorption," by Dr. W. P. Evans; "The Present State of our Knowledge of the Electrical Condition of the Atmosphere," by Dr. C. C. Farr; "The Structure and Habits of the New Zealand *Rotifera,*" by F. W. Hilgendorf, M.A., B.Sc.; "Provençal Troubadours," by Professor T. G. R. Blunt; "The Strength and Elasticity of some Australian and New Zealand Timbers," by Professor R. J. Scott.

The attendance at the ordinary meetings has averaged twenty-nine.

The Council has met eight times since the last annual meeting. At its request Dr. Dendy made enquiries when in London as to the probable cost of publishing the proposed "Index Faunæ Novæ-Zealandiæ." The result of his enquiries was very encouraging, and the Council, having received a very liberal offer from the editor, Captain F. W. Hutton, and being assured of the hearty co-operation of the Otago Institute, decided to proceed with the publication, and orders to that effect have been sent to Messrs. Dulau and Co., of London. The whole of the manuscript was forwarded to the printers before the end of 1902, and it is hoped that the work will appear during the coming session.

During the year many books and periodicals have been bound and added to the library. The arrangement made in 1901, by which periodicals are now obtained direct from Messrs. Dulau and Co., of London, is working satisfactorily.

The Hon. C. C. Bowen continues to represent the Institute on the Board of Governors of the New Zealand Institute, and the Council wishes to express the indebtedness of the Institute to him for his services. The thanks of the Institute are also due to Mr. G. E. Way, F.I.A.N.Z., the honorary auditor of the Institute.

The total number of members for 1902 was sixty-nine.

The balance-sheet shows that £67 14s. has been received for members' subscriptions, £40 8s. 8d. has been spent on books and periodicals, and £17 17s. 3d. on printing and binding; the credit balance in the bank on the 31st December, 1902, was £26 7s. 3d. The amount of invested funds arising from life members' subscriptions is now £82 6s. 2d.

ELECTION OF OFFICERS FOR 1903.—*President*—Professor Charles Chilton, D.Sc.; *Vice-presidents*—Mr. J. B. Mayne, B.A., Mr. A. E. Flower, M.A., B.Sc.; *Hon. Secretary*—C. Coleridge Farr, D.Sc.; *Hon. Treasurer*—Professor Charles Chilton, D.Sc.; *Council*—Miss M. F. Olliver, M.A., Captain F. W. Hutton, F.R.S., Professor W. P. Evans, Ph.D., Dr. W. H. Symes, Messrs. L. Cockayne and R. Speight, M.A., B.Sc.

The retiring President's address on "Bacteria and Fermentation" was postponed till the next meeting.

OTAGO INSTITUTE.

First Meeting: *13th May, 1902.*

Professor Benham, President, in the chair.

New Members.—Messrs. Alexander Michie, Percy R. Sargood, F. Z. Moore, Tompson Lamb, and Dr. Stevens.

Paper.—"The Marine *Mollusca* of Totaranui Bay, Nelson," by Professor Park. (*Transactions*, p. 299.)

Exhibits.—Mr. A. Hamilton showed a distorted stump of an elder-tree that had grown up between the University wall and the water-channel, and had burst up the latter.

The President exhibited a supposed hybrid between the common fowl and the weka, and showed that neither the external features nor the skeleton presented any approximation to the weka, but were entirely and absolutely galline.

Second Meeting: *10th June, 1902.*

Professor Benham, President, in the chair.

Mr. A. Bathgate moved the following resolution:—

That this Institute, having learned with regret that sheep are allowed to run upon the reserve at Mount Cook, and that the interesting native flora of that locality is consequently threatened with extinction, strongly urge on the Government the necessity for the immediate adoption of adequate measures to protect the reserve referred to from the depredations of stock and from injury by fire, and that the Government be asked to make and protect further reserves in that locality, including the country between the Tasman and Hooker Glaciers; and that a copy of this resolution be sent to the Hon. the Minister of Lands.

Mr. F. R. Chapman seconded and strongly supported the resolution, which was carried unanimously.

Miss M. E. A. Marchant, M.A., delivered an interesting address on "Impressions of Florence," formed during her recent visit to Europe.

After the address a fine series of lime-light views of the city and its chief architectural and historical places of interest was thrown on the screen.

THIRD MEETING: *8th July, 1902.*

Professor Benham, President, in the chair.

The Hon. Secretary brought up the following report regarding the marine fish-hatchery at Portobello:—

On 12th June an advisory board consisting of Mr. David Barron, Chief Surveyor of Otago; Mr. C. W. S. Chamberlain, Collector of Customs, Dunedin; Mr. Robert Chisholm, representing the Otago Acclimatisation Society; Captain C. E. W. Fleming, Superintendent of Mercantile Marine; and Mr. George M. Thomson, representing the Otago Institute, was gazetted. The first meeting of the Board was held on the 24th June, when Mr. George M. Thomson was elected Chairman. The members of the Board, along with Mr. L. F. Ayson, Inspector of Fisheries, visited the proposed site of the station on Saturday, 5th July, and were now getting plans and specifications of the required work ready.

Papers.—1. "On a Manifestation of Aurora in Southern Latitudes," by Mr. Henry Skey. (*Transactions*, p. 405.)

2. "The Kingston Moraine," by Dr. P. Marshall. (*Transactions*, p. 387.)

3. "Notes on the Occurrence of Native Lead at Parapara, Collingwood," by Professor James Park. (*Transactions*, p. 403.)

Mr. A. Hamilton exhibited fossil cetacean teeth from the phosphate-deposit at Millburn, and contrasted them with some from the Oamaru district, now in the Otago Museum.

Mr. Hamilton exhibited a stone relic (belonging to Mr. Dunlop, of the Orepuki Shale-works), which he believed to be unique, and which was perhaps a sacred relic brought by early immigrants from the Society Islands.

FOURTH MEETING: *12th August, 1902.*

Professor Benham, President, in the chair.

New Members. — Messrs. Thomas Brown and Robert Chisholm.

Paper.—Dr. Truby King gave a very interesting address on "Protection and Reclamation of Sea-coasts by means of planting."

Dr. King illustrated his remarks by lime-light illustrations and by a series of specimens of native and other plants used by him so successfully at Karitane.

The paper led to an interesting discussion, and the Chairman congratulated Dr. King on his very useful and instructive address.

Fifth Meeting: *14th October, 1902.*

Professor Benham, President, in the chair.

New Member.—Mr. J. S. S. Cooper, M.A., B.Sc.

Papers. — 1. "On *Tænia echinococcus* and Hydatid Disease," by Dr. Barnett.

In the course of his remarks the author stated that hydatid disease was much more prevalent in some countries than in others. It was most so in Iceland, where the disease accounted for quite one-tenth—some said one-sixth—of the inhabitants, the reason being that the people of Iceland were extremely filthy in their habits, their dogs sleeping with them in their huts. The disease was common in some of the Australian States, and there was far too much of it in New Zealand. Taking only the Government hospitals of the colony for the five years ending 1896, there were 146 cases of hydatid disease, and twenty-two deaths. For the five years ending 1901 there were 226 cases, with forty deaths, a large increase. Taking the four leading towns for five years ending 1901, in Auckland Hospital there were fifteen cases, with five deaths; at Wellington twenty-nine cases, with six deaths; at Christchurch twenty-five cases, with four deaths; and at Dunedin sixty-two cases, with nine deaths. This showed that Dunedin was more favoured by the disease than any other part of the colony. The lecturer then dealt with the leading points in the structure and history of the adult *Tænia*, which he stated was found in the dog alone, and he ventured to say that locally every second dog would be found affected. As for live-stock, almost every animal killed for consumption had the hydatid cystic stage present in its viscera, though this did not affect it as food. As for the dogs, they could hardly help becoming contaminated, as the offal from the animals killed was thrown to them. There was a law preventing its being thrown to pigs; but, strange to say, none in regard to the dog, the only animal in New Zealand that could disseminate the disease. This, he had shown, was increasing in Otago, and things should not be allowed to go on as at present. He then indicated how the spread of the disease was to be prevented, laying particular emphasis on the treatment of dogs, and the avoidance of the use of impure drinking-water.

The paper evoked considerable discussion, both the Chairman and Mr. G. M. Thomson suggesting that it was a matter for investigation by medical men.

2. "An Account of the Fiji Fire-walking Ceremony, or *Vilavilairevo*, with a Probable Explanation of the Mystery," by Dr. B. Fulton. (*Transactions*, p. 187.)

The Chairman announced that Mr. J. C. Thomson had been elected to fill a vacancy on the Council.

Sixth Meeting: *14th October, 1902.*

Professor Benham, President, in the chair.

Papers.—1. "On the Wanganui Gravels," by Dr. P. Marshall.

2. "Some New Species of New Zealand Earthworms,' by Professor Benham. (*Transactions*, p. 277.)

3. "An Earthworm from Norfolk Island," by Professor Benham. (*Transactions*, p. 273.)

4. "On an Earthworm from the Auckland Islands—*Notiodrilus aucklandicus*, n.s.," by Professor Benham. (*Transactions*, p. 275.)

In connection with these papers the Chairman gave an account of the geographical distribution of this group of animals.

Exhibits.—Professor Benham showed (1) a giant limpet (*Patella*) from the Kermadec Islands, and (2) a specimen of a crinoid mounted above a piece of mirror so as to enable all its aspects to be seen.

ANNUAL MEETING: *11th November, 1902.*

Professor Benham, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

Since last annual meeting the Council has met seven times for the transaction of business. At the first meeting Mr. George M. Thomson, who had been elected Vice-president as well as Honorary Secretary, resigned the former position, and the Council unanimously elected Mr. F. R. Chapman a Vice-president. During the year Mr. T. D. Pearce forwarded his resignation as a member of the Council. This was accepted with regret, and Mr. J. C. Thomson was elected to the vacancy.

The additions to the membership during the year were twelve, the total number now on the roll being 112, of whom ten are life members.

Seven general meetings of the members have been held, and at these there has been, on the whole, a gratifying attendance. At two of these, interesting addresses illustrated by lime-light views were delivered—viz., by Miss M. E. A. Marchant on "Impressions of Florence," and by Dr. F. Truby King on "Protection and Reclamation of Sea-coasts by means of planting." The following papers were also contributed: "The Marine *Mollusca* of Totaranui Bay, Nelson," by Professor Park; "Occurrence of Native Lead at Parapara, Nelson," by Professor Park; "On a Manifestation of Aurora in Southern Latitudes," by Mr. H. Skey; "The Kingston Moraine," by Dr. P. Marshall; "The Wanganui Gravels," by Dr. P. Marshall; "On *Tænia echinococcus* and Hydatid Disease," by Dr. L. E. Barnett; "An Account of the Fiji Fire-walking Ceremony, or *Vilavilairevo*, with a Probable Explanation of the Mystery," by Dr. R. Fulton; "Some New Species of New Zealand Earthworms," by Professor Benham; "An Earthworm from Norfolk Island," by Professor Benham; "The Evolution of Life," by Professor Benham.

At the last annual meeting it was resolved that the Institute be registered under "The Unclassified Societies Act, 1895." Steps were taken in accordance with this resolution; but, as the Registrar of Friendly Societies required the rules to be amended, a special meeting of the members, called by circular, was held on the 13th May, when a draft of proposed rules and regulations was adopted. On the 8th July the certificate of incorporation and a sealed copy of the rules were laid on the table, and it was resolved to deposit the same with the Institute's solicitors.

At the June meeting of the members the following resolution, moved by Mr. A. Bathgate, was agreed to: "That this Institute, having learned with regret that sheep are allowed to run upon the reserve at Mount Cook, and that the interesting native flora of that locality is conse-

quently threatened with extinction, strongly urges on the Government the necessity for the immediate adoption of adequate measures to protect the reserve referred to from the depredations of stock and from injury by fire, and that the Government be asked to make and protect further reserves in that locality, including the country between the Tasman and Hooker Glaciers; and that a copy of this resolution be sent to the Hon. the Minister of Lands." In reply to the Secretary's communication the Minister of Lands stated that instructions had been issued to the Commissioner of Crown Lands for Canterbury, the Crown Lands Ranger, and other officials to report as to the facts of the case.

Reference was made in the last annual report to the compilation of an "Index Faunæ Novæ-Zealandiæ," which it was hoped the Governors of the New Zealand Institute would publish. This the Governors did not see their way to do, and accordingly the Canterbury Philosophical Institute had itself undertaken to publish the work at joint risk with Captain Hutton, the editor. Your Council resolved to co-operate with the Canterbury Philosophical Institute by subscribing for fifty copies at 10s. each.

The matter of the marine fish-hatchery has been moved a step forward, and is now out of the hands of your Council, except as regards the appointment of a representative on the advisory board and its liability of £250 towards the cost of construction of the station. On the 10th March Professor Benham, Messrs. A. C. Begg, F. R. Chapman, R. Chisholm, and G. M. Thomson waited on the Premier as a joint deputation from the Institute and the Otago Acclimatisation Society, and received an assurance from him that the Cabinet had agreed to push on with the matter. In consequence of a letter received from the Marine Department, a conference of your Council with the committee of the Acclimatisation Society was held on the 21st March. The letter stated that the Government was prepared to form an advisory board in connection with the marine fish-hatchery, and to go on with the construction at a cost not to exceed £1,100: the Board to consist of one member from the Otago Institute; one member from the Otago Acclimatisation Society; the Commissioner of Customs, Dunedin; the District Engineer, Public Works Department, Dunedin; and the Chief Surveyor, Otago District. After discussion it was agreed, "That, if it be understood that the advisory board shall have the management subject to the control of the Department, and that the representation of the societies be increased to two members each, the societies will agree to the Government proposals." On the 12th June an advisory board consisting of Mr. David Barron, Chief Surveyor; Mr. C. W. S. Chamberlain, Collector of Customs; Mr. Robert Chisholm, representing the Otago Acclimatisation Society; Captain C. E. W. Fleming, Superintendent of Mercantile Marine; and Mr. G. M. Thomson, representing the Otago Institute, was gazetted. Although this is not in accordance with the foregoing resolution, your Council, being desirous of seeing the work proceeded with, did not think it advisable to press the matter. On the 24th June the first meeting of the Board was held, when Mr. George M. Thomson was elected Chairman, and Mr. C. W. Chamberlain Hon. Secretary.

Early in the session a letter was received from the Council of the Auckland Institute in regard to the delay in publication of the Transactions, and suggesting (1) the issue of the annual volume in parts, these parts either to appear at fixed periods or as soon as sufficient material is available; (2) that no papers forwarded to the Manager of the Institute later than 31st December in each year shall appear in the volume for that year. In reply, the Secretary was requested to write expressing the concurrence of this Council with the proposals of the Auckland Institute, and further to suggest that the Proceedings should be published separately from the Transactions immediately after the close of each session, or in two separate instalments during and after each session.

The last instalment due on the moa's egg in the Museum having been paid to the Council during this session, the egg is now the property of the Otago University.

Your Council has nominated Mr. James McKerrow as its representative on the Board of Governors of the New Zealand Institute, and has forwarded the names of the following gentlemen as honorary members for any vacancies which may occur in the list: Dr. George S. Brady, F.R.S., Durham College of Science, author of papers on New Zealand *Entomostraca;* Frank E. Beddard, F.R.S., Prosector of the Zoological Society of London, who has worked on New Zealand Annelids; George O. Sars, Professor of Zoology in Christiana, for work on New Zealand *Crustacea.*

The following books have been added to the library of the Institute during the session: Benham, W. B. "Platyhelmia"; Cambridge Natural History:—Beddard, "Mammalia," and Gadow, "Amphibia and Reptilia"; Christian, "The Caroline Islands"; Cole and Johnstone, "Pleuronectes"; English Dictionary, Murray, 2 vols.; Flower and Lydekker, "Mammals"; Keane, "Man, Past and Present"; Kent, W. Saville, "The Naturalist in Australia"; Lloyd, Morgan, "Animal Behaviour"; Moore, "To the Mountains of the Moon"; Packard, "Lamarck, his Life and Letters"; Skeat, "Malay Magic."

The following books are now under order: Ratzel, "History of Mankind"; Meakin, Bridget, "The Moors"; Scientific Memoirs, edited by Dr. J. S. Ames, 15 vols.; Thomson, Basil, "Savage Island"; the Gilbert Club, "William Gilbert, of Colchester, on the Magnet," &c.

The balance-sheet shows that the total receipts for the year were £135 13s. 11d., and the expenditure £63 5s. 9d. The Assets Account shows that the sum of £450 is now on deposit, and that the bank balance amounts to £51 19s. 2d.

Election of Officers for 1903.—*President*—A. Hamilton; *Vice-presidents*—Professor Benham and George M. Thomson; *Hon. Secretary*—Dr. P. Marshall; *Hon. Treasurer*—Willi Fels; *Council*—A. Bathgate, C. W. S. Chamberlain, F. R. Chapman, J. S. S. Cooper, James C. Thomson, D. Waters, and Dr. Hocken; *Hon. Auditor*—D. Brent.

The retiring President, Professor Benham, then read his address on "The Evolution of Life."

Papers.—1. "The Geology of the Rock-phosphate Deposits of Clarendon, Otago," by Professor James Park. (*Transactions*, p. 391.)

2. "On a Stone Relic found at Orepuki, Southland," by A. Hamilton. (*Transactions*, p. 113.)

WESTLAND INSTITUTE.

ANNUAL MEETING.

Dr. Teichelmann, President, in the chair.

ABSTRACT OF ANNUAL REPORT.

In presenting the thirty-sixth annual report the trustees are glad to be able to report a considerable advance in the utility of the society, and especially an increase in number of its members, amounting to nineteen, during the past year.

Seven ordinary meetings were held, and were generally well attended. A new catalogue was printed and issued to members. A considerable number of these were posted for inspection to residents in the town and district who were not members, and to this is largely attributable the increase in membership.

New editions of some of the standard authors have been procured to replace worn copies.

The expense of repairs and shelving was considerable, and half the cost of this was borne by the Borough Council.

One hundred and fifteen volumes have been added to the library.

The Museum, under the care of the Honorary Curator, Dr. Macandrew, has been improved by the addition of new specimens, and some of the old ones have been relabelled with the assistance of Mr. Goodlet, of the Otago University.

A number of newspapers have, as usual, been forwarded gratis to the Institute by their proprietors, for which the trustees beg to return thanks.

Notwithstanding the considerable increase in membership this year, there is still room for great improvement in this respect, and the trustees feel that in a place of the size and importance of Hokitika an Institute such as ours should be very much better supported, and it is to be hoped that the coming year will show a great increase in membership.

The Treasurer, Mr. McNaughton, submitted his annual statement of the financial position of the Institute, which he set forth in full detail. He explained that in the past year a very large amount of permanent renovation had been done. Nevertheless, their funds were in a very satisfactory state. The usual subsidies from the Government, the Borough Council, and the Harbour Board have been received.

The report and balance-sheet were unanimously adopted.

ELECTION OF OFFICERS FOR 1903.—*President*—Mr. J. B. Lewis; *Vice-president*—Mr. T. W. Beare; *Treasurer*—Mr. McNaughton; *Committee*—Messrs. Clarke, Heinz, D. Macfarlane, Michel, Morton, Park, G. Perry, Mahan, Dunne, Solomon, and Drs. Macandrew and Teichelmann.

Votes of thanks were passed to Dr. Teichelmann, the retiring President, for the active interest he had taken in the management of the institution, and also to the Vice-president, Treasurer, and Auditors.

Dr. Teichelmann and Messrs. Lewis and Morton were appointed a book-selection committee by the Council.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

First Meeting: *19th May, 1902.*

The President, Dr. Leahy, delivered the inaugural address, taking as his subject "The Fight against Tuberculosis in the Australian Colonies and New Zealand." (*Transactions*, p. 220.)

Second Meeting: *21st July, 1902.*

Paper.—"The Birth and Development of Architecture," by R. N. Anderson.

The lecture was illustrated by seventy-five lantern-slides.

Third Meeting: *11th August, 1902.*

Paper.—"Technical Education," by H. Hill, B.A., F.G.S. (*Transactions*, p. 153.)

Fourth Meeting: *15th September, 1902.*

Paper.—"The Honey-bee as seen through the Microscope," by Dr. Kennedy, M.A.

This lecture was illustrated by over fifty photomicrographs.

Fifth Meeting: *13th October, 1902.*

Papers.—1. "Wagner," by H. Large.

Several selections were given in illustration.

2. "The Maori To-day and To-morrow (No. 2)," by H. Hill, B.A., F.G.S. (*Transactions*, p. 169.)

3. "The Horse: a Study in Philology," by Taylor White. (*Transactions*, p. 211.)

4. "The Travelled Goat," by Taylor White. (*Transactions*, p. 209.)

Sixth Meeting: *1st December, 1902.*

Paper.—"On the Tracks of Captain Cook," by Russell Duncan. (*Transactions*, p. 32.)

The lecture was illustrated by lantern-slides.

Annual Meeting.

Abstract of Annual Report.

Including the annual business meeting, there have been seven meetings of the Institute during the year just ended. The ordinary meetings were devoted to papers and popular lectures, there being six papers read during the session, and three illustrated lectures delivered. At most of the meetings the attendance of members and the general public was very satisfactory. Five Council meetings were held during the year.

The library has received a good deal of attention, and forty-seven new volumes have been added. Orders have also been given for the supplementary volumes of the "Encyclopædia Britannica," "Index Faunæ Novæ-Zealandiæ," and Hudson's "Neuroptera."

The following specimens and curios have been donated to the Museum: Three cases of moths and butterflies, one Mahratta dagger, one Mahratta sword, all presented by Mrs. Buckman; one whalebone *mere*, by Mr. J. F. V. Williams; and a collection of rock specimens, by Mr. E. Lyndon. Mr. C. W. Andrews has been appointed Curator of the Museum.

During the year four members withdrew from the branch, and two new members were elected, leaving the membership at sixty-two.

The Treasurer's balance-sheet shows the Institute in a satisfactory financial position, the total receipts (including balance carried forward) being £93 5s. 3d., and the expenditure £61 5s. 2d., leaving a balance to the Society's credit of £32 0s. 1d. Of the "Colenso bequest" £84 17s. 10d. remains to credit.

Election of Officers for 1903.—*President*—J. P. D. Leahy, M.B., M.S., B.A., D.P.H.; *Vice-president* — T. C. Moore, M.D.; *Council*—W. Dinwiddie, H. W. Antill, H. Hill, B.A., F.G.S., F. Hutchinson, jun., J. S. Large, T. Tanner; *Hon. Secretary*—James Hislop, District School; *Hon. Treasurer* —J. W. Craig; *Hon. Auditor*—G. White; *Curator*—E. W. Andrews.

NELSON INSTITUTE.

Annual Meeting: *25th February, 1903.*

Abstract of Annual Report.

The receipts for the year from all sources (including balance, £19 7s., brought forward) amounted to £243 2s. 8d., and the expenditure to £236 19s. 6d., leaving a credit balance of £6 3s. 2d. This small amount to credit is accounted for by the unusual expenditure of over £25 in connection with the Gordon Downs Accommodation-house. It will be noted with satisfaction that the receipts from subscriptions amounted to £167 17s. 9d., as against £129 16s. for the previous year, representing an increase of about thirty-eight members.

Some necessary repairs have been made to the Gordon Accommodation-house at the request of the Licensing Bench, and £25 has been expended on this property during the year, as stated above. The new tenant has effected considerable improvements on the land during the short time he has had possession.

The committee have received an offer to lease the Tadmor Block at a low rental, but have declined the offer, considering it better to defer dealing with it until the Tadmor section of the railway, now in progress, is completed, when it is considered a better rental will be obtained.

About two hundred volumes of new works have been purchased during the year. Several new magazines and periodicals have been added, and an excellent collection of the best illustrated papers, reviews, magazines, and periodical literature is available for readers and for circulation.

The free reading-room has been well attended during the year.

The committee have extended the hours, for convenience of members, during which the library is open, from 5 to 5.30 p.m. and from 9 to 9.30 p.m., and trust that the increased prosperity of the Institute may enable them in the future to still further extend the hours.

The committee desire to record their thanks to members who have kindly placed newspapers and periodicals in the reading-rooms, and to those who have generously presented books, and would again wish to express their appreciation of the courteous and efficient manner in which the duties of Librarian have been carried out by Miss Reeves.

Election of Officers for 1903.—*President*—H. W. Robinson; *Vice-president*—D. Grant; *Secretary*—A. J. Redgrave; *Librarian*—R. Reeves.

APPENDIX

ETE(LOGY.

COMP. ATIVE AB 1902 and Previou Yea

Stations.	Barometer at 9.30 a.m. Mean Reading.	Barometer at 9.30 a.m. Extreme Range.	Temperature from Self-registering Instruments read in Morning for Twenty-four Hours previously. Fahr. Mean. Temp. in Shade.	Mean Daily Range of Temp.	Extreme Range of Temp.	Max. Temp. in Sun's Rays.	Min. Temp. on Grass.	Computed from Observations. Mean Elastic Force of Vapour.	Mean Degree of Moisture (Saturation = 100).	Rain. Total Fall in Inches.	No. of Days on which Rain fell.	Wind. Average Daily Force in Miles for Year.	Maximum Velocity in Miles in any 24 hours, and Date.	Cloud. Mean Amount (0 to 10).
Auckland...	30·062	1·270	57·4	11·3	41·5	144·0	35·0	0·322	67·2	38·280	184	*205·9	*603 on 7th Mar.	5·0
Previous 38 ye rs ...	30·000	...	58·8	...	...	...	...	0·379	70·9	41·791	180	...		...
Wellington	29·928	1·726	54·1	12·8	49·0	136·0	24·0	0·299	70·5	38·750	201	226·0	720 on 15th Nov.	5·8
Previous 38 ye rs ...	29·920	...	54·9	...	...	...	...	0·329	71·9	50·906	161	...		...
Dunedin	29·806	1·784	48·5	12·5	57·0	...	...	0·273	80·6	53·564	184	172·4	530 on 1st Sept.	6·0
Previous 38 ye rs ...	29·943	...	50·1	...	...	...	...	0·274	73·1	36·934	158	...		...

* For seven months only.

AVERAGE TEMPERATURE OF SEASONS compared with those of the Previous Year.

Stations.	Spring. September, October, November. 1901.	1902.	Summer. December, January, February. 1901.	1902.	Autumn. March, April, May. 1901.	1902.	Winter. June, July, August. 1901.	1902.
Auckland	57·0	54·6	63·4	63·8	59·5	59·9	53·0	51·1
Wellington	56·2	51·3	60·6	60·7	56·6	56·2	48·3	48·3
Dunedin	50·8	46·9	54·9	54·9	50·1	49·5	41·6	42·7

REMARKS ON THE WEATHER, 1902.

January.—Hot and calm with but little rain over North Island and east coast of South Island. Heavy rain with thunder over west coast of South Island. Wind prevalent in both Islands towards the close of the month.

February.—Fine and warm over the north and centre; the rains not quite up to the average. Good rains on west coast and south of South Island.

March.—Prevailing winds W. and S.W., the rainfall being slightly under the average everywhere except Dunedin.

April.—Thunder in the extreme north. Good rain all over; prevailing wind from the S.W.

May.—Wet in the north, centre, and the west coast of South Island; but small rains over the East Coast. Prevailing wind, S.W.

June.—Fine in the north; wet and changeable over the centre and south. Continued gales with rain were felt over the centre about the middle of the month. The rain not quite up to the average anywhere.

July.—Calm and fine all over. Wind mostly from the S.W., and but poor rains. Snow fell in the south on 14th.

August.—Generally fine, the rainfall being small all over. Snow in the south.

September.—Good rains in the north; wet and cold with S.W. winds and snow in the centre and south. In N.E. of South Island and centre changeable and wintry.

October.—Windy in the north; small rainfall everywhere, except the west coast of the South Island. Snow in the south.

November.—Fine all over at the beginning of the month, but later on cold and boisterous. Rain under the average in the north of North Island and east coast of the South.

December.—Rain under the average in the north. Elsewhere wet and cold; W. and S.W. winds prevailing. Hail over the north.

EARTHQUAKES reported in NEW ZEALAND during 1902.

PLACE.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Opotiki ..	..	..	12*	..	..	..	..	..	..	..	..	..	1
Rotorua ..	5, 11	..	..	25	10, 12, 16	12*	15, 21, 27	..	..	..	..	..	10
Gisborne ..	..	..	..	..	16	..	..	..	..	..	..	..	1
New Plymouth ..	..	25	..	27*	9	17,20, 21, 30	16*	..	..	..	1, 4*	28,* 29*	12
Inglewood ..	..	..	..	..	..	..	..	..	..	..	..	29*	1
Napier ..	..	..	..	8,* 27*	..	9*	18	..	..	..	..	..	4
Eltham ..	..	..	..	..	..	..	..	..	..	..	..	28	1
Stratford ..	..	..	..	..	..	..	..	..	..	..	..	29*	1
Hawera ..	..	..	..	27	..	..	..	..	..	..	..	28,* 29	3
Wanganui ..	..	..	..	27	16	..	..	..	..	..	..	29	3
Waipawa ..	..	..	..	..	..	..	..	..	..	..	15*	..	1
Dannevirke ..	..	..	..	..	8	..	..	..	..	..	..	..	1
Feilding ..	..	..	..	27	8*	..	..	26	..	..	..	29	4
Pahiatua ..	..	..	..	..	8*	..	..	..	..	..	..	..	1
Masterton ..	..	21	..	..	..	..	..	..	..	..	..	..	1
Greytown ..	..	21*	..	..	..	..	..	..	..	..	..	..	1
Carterton ..	..	..	..	..	8	..	..	26	..	..	..	..	2
Wellington ..	..	21	..	27,* 28	8, 16	..	18	..	22	14	..	28, 29*	10
Kaikoura ..	..	..	..	..	22*	..	..	..	..	..	..	..	1
Cheviot ..	5	..	..	4*	9	..	..	..	..	..	..	..	3

NOTE.—The figures denote the day of the month on which one or more shocks were felt. Those with the asterisk affixed were described as *smart*. The remainder were only slight tremors, and no doubt escaped record at most stations, there being no instrumental means employed for their detection. These tables are therefore not reliable as far as indicating the geographical distribution of the shocks within New Zealand. The records of the Milne seismographs recently established at Wellington and Christchurch will be found on p. 582 *et seq*.

Records of Milne Seismograph No. 20, at Wellington, from January, 1902, to December, 1902 (inclusive).

Plates LIII. and LIV.

atitude, 41° 17′ S.; longitude, 174° 47′ E. Greenwich mean civil time. Midnight, 0 h. or 24 h.; hours, 1 to 24. Time in hours, minutes, and tenths of minutes.

Record numbers 1, 2, . . . from the 1st October, 1900. P.T., preliminary tremors. A.T., after-tremors. B., E., eginning and end of vibrations generally not less than 2 mm. Amp., full amplitude in millimetres.

The instrument is placed in a special room below a house standing about 30 ft. from the edge of a rocky cliff about 50 ft. igh, situated about 250 yards from the shore-line of Wellington Harbour.

George Hogben, Observer.

No.	Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1902.					Mm.			
200	Jan. 2	5.45·5	..	..	..	..	..	6.22·0	Very small tremors.
201	" 14	..	..	2.19·8	..	..	..	..	Three small local shocks.
				2.24·8	2.30·8	1·0			
202	" 14	..	..	16.37·8	..	1·0	..	..	One local shock.
203	" 18	0.39·0	..	..	..	..	..	6·35·0	Very small tremors.
204	" 18	..	..	9.26·0	..	3·0	..	..	Local.
205	" 19	..	..	3.34·0	..	4·0	..	..	Three local shocks.
				7.07·5	..	7·0			
				7.16·0	7.19·0	7·0			
206	" 19	..	..	10.51·0	..	2·0	..	..	
				11.31·3	..	1·5			
				11.34·0	..	3·5			
207	" 24	23.36·8	..	23.41·5	..	1·75	23.45·3		
	" 25	..	..	..	..	..	..	0.09·3	
208	Feb. 9	7.41·8	7.45·8	7.46·5	..	6·0	7.52·3	8.58·5	
209	" 16	†10.10·0	..	..	..	..	..	†22·00·0	Very minute tremors.
210	" 24	†16.50·0	..	..	..	..	..	..	P.T., small; A.T., minute.
	" 25	..	..	3.35·5	..	1·5	..	†10·30·0	(Boom-period, 16·5 sec.)

211	Feb.	25	14.27·0							
	"	26	..	..	16.17·0	..	1·5	..		
	"	27	..	..	..	..	..	..	11.17·0	
212	Mar.	1	..	..	15.41·0	.	..	..	..	Small local shock.
213	"	1	20.20·0	..	..	..	..	..	?	Small tremors.
214	"	5	19.24·3	19.48·3	19.54·5	20.03·5	3·5	20.07·3	..	A.T., very small.
	"	6	..	..	..	..	..	..	0.30·0	
215	"	6	8.50·5	..	..	..	..	..	14.13·3	Very small tremors.
216	"	7	17.02·0	..	..	..	..	..	..	Tremors minute with intervals of rest, but increasing from 20h. on 11th March.
	"	11	..	..	20.13·0	..	2·0	..	..	
	"	12	..	..	..	..	..	..	4.25·0	
217	"	12	..	15.14·0	15.15·0	*15.22·8	9·6	15.31·0	16.42·8	* Prin. maximum at 15.21·5.
218	"	13	13.27·3	..	..	..	..	..	..	Tremors mostly minute.
	"	14	..	..	..	..	..	..	7.32·0	
219	"	14	20.57·5	..	..	..	..	..	22.46·5	Minute tremors.
220	"	15	8.08·5	19.22·0	19·24·8	..	2·75	..	..	Tremors, small for eight hours, with three other maxima not quite so large between, and several smaller afterwards; then tremors till *; then tremors dying away.
	"	16	..	..	..	0.06·5	2·25	..	..	
	"	17	..	..	..	*2·10·5	2·5	..	..	
	"	18	..	..	..	..	..	..	†7.00·0	
221	"	18	16.36·0	..	..	..	..	..	22.20·0	Very minute tremors.
222	"	19	20.31·0	..	23.34·0	..	1·0			
	"	20	..	..	..	..	..	..	7.05·8	
223	"	20	..	15.27·8	15.28·5	..	1·0	..	15.32·0	(Boom-period, 15 sec.)
224	"	20	20.44·0	..	..	..	..	..	?	Very minute tremors for about six hours.
225	"	21	†17.40·0	..	..	..	..	..	..	Minute tremors.
	"	22	..	..	..	..	..	..	†7.30·0	
226	"	22	22.55·0	..	..	..	..	..	..	(Boom-period, 18 sec.) Tremors minute.
	"	23	..	1.33·0	1.39·0	..	1·25	1.51·8	10.00·5	
227	"	24	..	..	22.19·0	..	1·0	..	..	Local.
228	"	25	19·49·0	..	..	..	..	..	..	Very minute tremors.
	"	26	..	..	..	..	..	..	10.18·5	
229	"	26	†20.30·0	..	..	..	..	..	..	Occasional minute tremors.
	"	27	..	..	..	..	..	..	†8.30·0	

[NOTE.—During January I was away from home, and the instrument was not kept sensitive enough, the boom-period being only about 12 sec. to 14 sec.—G. H.]

† About.

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued*.

No.	Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1902.					Mm.			
230	Mar. 28	..	5.48·8	5.51·0	..	2·0	5.54·5	..	A few minute tremors between.
	" 28	9.48·8	10·02·0	10.03·0	10.07·0	1·5	10.12·5	..	
231	" 28	..	..	10.16·0	..	3·0	..	..	Local.
232	" 28	14·54·0	15.03·3 or 15.17·5	15.19·0	15.32·3	8·0	15.43·0	?	Decided motion began at 15.3·3, but still more marked at 15.17·5.
233	" 28	16·55·5	17.01·8	17.11·8	17.16·3	3·5	17.32·8	?	Probably "repeats" of No. 232.
234	" 28	?	18.08·0	18.11·8	18.13·0	2·0	18.18·5	?	
235	" 28	?	20.13·8	20.24·3	20.31·0	1·0	20.37·8	?	
236	" 28	?	22.26·3	22.31·0	22.37·8	1·0	22.42·5	?	
237	" 29	..	..	6.56·5	..	1·5	..	..	Probably local.
238	" 30	†1.00·0	..	..	..	..	..	†4.15·0	Minute tremors.
239	" 30	19.03·0	..	19.16·0	..	1·0	..	?	Followed by minute tremors for about eight hours and a half.
240	" 31	15.56·3	16.01·0	16.04·8	16.10·0	2·0	16.11·5	16.13·8	
241	" 31	21.18·0	..	..	..	..	..	..	Very minute tremors.
	April 1	..	..	..	..	..	..	10.45·5	
242	" 1	†18.00·0	..	..	..	..	..	..	Minute tremors.
	" 2	..	..	..	..	..	..	†1.50·0	
243	" 2	19.37·0	..	..	..	..	..	..	Minute and small tremors, with a few very small shocks; ? Cheviot.
	" 3	..	..	..	..	..	..	7.46·0	
244	" 5	..	..	13.10·8	..	4·5	..	..	(Boom-period, 17·5 sec.
245	" 6	..	11.13·8	11.15·3	..	7·0	11.22·5	?	Local; tremors minute between and after second shock.
246	" 6	..	21.59·0	22.00·5	..	1·2	22.02·5	..	(Boom-period, 18 sec.)
247	" 7	..	2.34·5	2.35·5	..	0·8	2.37·8	..	Very minute tremors between.
248	" 7	..	5.40·0	5.49·3	..	1·5	5.50·0	..	
249	" 7	..	8.03·0	8.06·3	..	0·8	8.08·8	..	
250	" 7	20.33·5	..	..	..	..	..	..	Tremors minute and very small, with very small shocks.
	" 8	..	..	..	..	..	..	14.08·5	

251	April	10	..	14.50·5	14.51·0	..	?	14.52·3	..	Very small.
252	"	10	..	20.21·0	..	..	?	20.24·3		
253	"	10	23.34·0	..	..	..	..	..	..	Tremors minute, increasing for seventeen hours; then small for thirty hours; then minute.
	"	13	..	..	..	..	..	..	8.00·0	
254	"	13	20.43·5	..	..	..	..	..	..	Very small, three hours; minute, thirteen hours; then small for four hours.
	"	14	..	..	15.29·8	..	?	..	22.40·5	
255	"	15	23.58·3	..	..	..	..	..	..	Minute tremors, with small shocks.
	"	16	..	..	1.44·0	..	0·8	..	8.33·0	
256	"	16	23.26·5	..	..	..	..	..	..	Several small and minute tremors.
	"	17	..	..	..	..	..	..	9.48·5	
257	"	17	20.44·0							
	"	18	..	..	..	..	..	..	2.38·0	
258	"	19	2.38·0	2.47·5	2.49·5	..	..	..	..	Guatemala EQ.
			..	..	3.18·5	3.39·5	40+	..	5.09·3	
259	"	20	..	19.18·5	..	..	?	19.33·0	..	Small tremor.
260	"	20	..	20.44·0	20.48·3	..	2·5	20.53·0		
261	"	20	..	21.44·5	..	..	?	21.51·0		
262	"	22	10.24·0	..	..	..	..	..	†16.00·0	Tremors.
263	"	23	5.23·0	..	..	..	..	..	8.07·0	Minute tremors.
264	"	23	18.58·0	..	..	..	..	..	..	Several minute tremors and small shocks.
	"	24	..	..	..	..	..	..	5.41·0	
265	"	24	20.42·0	..	..	..	..	..	..	Very small tremors.
	"	25	..	..	..	..	..	..	22.29·0	
266	"	25	†6.00·0	..	..	..	..	..	†7.40·0	Minute tremors.
267	"	25	19.27·0	..	..	..	..	..	?	Very minute tremors.
268	"	30	8.59·0	..	..	..	..	..	..	Many small tremors and shocks.
	May	2	..	..	..	..	..	..	8.15·0	
269	"	3	22.44·0	..	..	..	..	..	..	Minute tremors. (Boom-period, 18 sec.)
	"	4	..	..	..	..	..	..	9.56·0	
270	"	4	21.58·0	..	..	..	..	..	22.45·0	Minute tremors.
271	"	5	21.04·0	..	..	..	..	..	..	"
	"	6	..	..	..	..	..	..	14.44·0	
272	"	7	..	..	10.18·8	..	5·0	..	..	? Local.
273	"	7	..	..	15.31·3	..	..	..	..	Tilt 1·5 mm. west.
274	"	7	21.37·0	..	..	..	*v. sm.*	..	10.38·5	P.T. and A.T. minute. Caribbean Sea.
	"	8	2.54·3	..	2.14·0	3.09.3	1·5	3.11·0	..	
275	"	8	13.25·8	..	13.26·0	..	1·75	13.31·8	..	? Martinique.

† About

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

No.	Date.		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1902.						Mm.			
276	May	8	19.30·8	..	..	..	..	..	..	Minute tremors. ? Martinique.
	"	9	..	..	..	..	..	..	9.41·3	
277	"	9	20.02·0	..	..	..	..	..	..	Tremors minute.
	"	10	..	..	9.29·8	..	1·0	..	11.47·0	
278	"	10	21.59·0	..	..	..	..	..	..	Five small shocks between * * (all about 0·5 mm.). ? Local or from Martinique.
	"	11	..	..	19.26·8	*19.28·3	1·0	..	..	
279	"	12	..	..	*3.51·5	..	2·0	15.23·5	..	
280	"	12	10.55·3	..	13.40·8	14.46·0	2·0	14.50·5	..	Other small maxima at 15.33·5 and 20.39·0; not local, but apparently not very distant.
	"	13	..	..	..	..	..	..	1.24·8	Tremors minute.
281	"	13	5.51·0	..	..	..	..	..	13.02·0	Minute tremors.
	"	13	13.02·0	16.09·0	16.29·0	..	3·0	..	..	A.T. mostly minute.
	"		..	..	16.53·5	..	3·0	..	..	
	"	to	..	..	16.56·0	..	3·0	..	..	
	"		..	..	18.09·0	..	3·0	18.22·0	..	
	"	15	..	..	..	..	..	..	19.44·0	
282	"	16	14.49·0	..	..	..	..	..	..	Tremors small and minute.
	"	17	..	..	..	..	..	..	0.02·0	
283	"	17	20.04·0	..	..	..	..	..	..	Minute tremors.
	"	18	..	..	..	..	..	..	6.13·0	
284	"	18	8.16·0	..	..	..	..	..	10.21·0	Very minute tremors.
285	"	18	†17.20·0	..	..	..	..	..	..	"
	"	19	..	..	..	..	..	..	2.35·0	
286	"	19	13.26·0	..	..	..	..	..	16.56·0	"
287	"	19	19.50·0	..	..	..	..	..	..	Minute tremors.
	"	20	..	..	..	..	..	..	22.45·0	
288	"	21	23.28·0	..	..	..	..	..	..	Small tremors followed by minute tremors. * Local shock perhaps not connected with tremors.
	"	22	..	..	*10.05·5	..	..	..	17.17·0	

289	May	23	11.24·0	..	..	..	..	..	22.24·0	Small tremors.
290	"	24	..	..	3.14·5	..	2·0	..	8.05·0	Local; A.T. minute.
291	"	24	13.30·0	..	*23.35·5	..	1·6	..	..	* Tremors small and minute. * Local shock.
	"	25	..	..	..	..	..	..	†10.00·0	
292	"	26	†11.00·0	..	..	..	..	..	..	Tremors mostly minute; several very small local shocks.
	"	27	..	..	..	..	..	..	†8.00·0	
293	"	27	15.37·0	..	..	..	..	..	..	Minute tremors.
	"	28	..	..	..	..	..	..	2.41·0	
294	"	28	†11.50·0	..	..	..	..	..	†14.15·0	"
295	"	30	7.23·0	..	..	..	..	..	?	Very minute tremors for about twelve hours.
296	"	31	6.24·0	..	..	..	..	..	7.47·0	Very small tremors.
297	"	31	..	..	9.51·0	..	?	..	..	Very small local shock.
298	"	31	†13.15·0	..	..	..	..	..	..	P.T. very small for twelve hours; then small for ten hours; large for three hours; then dying away.
	June	1	..	..	22.01·0	..	3·2	..	?	
299	"	2	..	..	8.46·0	..	2·0	..	..	Local.
300	"	3	0.49·0	..	..	..	..	..	1.14·0	Small tremors.
301	"	4	1.00·0	..	..	..	..	..	?	Minute tremors for about six hours and a quarter.
302	"	4	..	..	21.38·0	..	?	..	..	Very small local shock.
303	"	5	20.46·0	..	..	..	..	..	20.56·0	Very small tremor.
304	"	11	21.20·0	..	..	..	..	..	..	(Boom-period, 16 sec.) P.T. and A.T. minute.
	"	12	..	0.09·0	?	..	1·0	0.15·0	6.07·0	
305	"	12	12.33·0	..	..	..	..	..	..	(Boom-period, 17 sec.) P.T. minute for about four hours; then small, with some very small shocks (? local). A.T. very minute.
	"	15	..	12.26·5	12.31·0	..	5·2	12.32·3	..	
	"	16	..	..	..	..	..	..	†4.15·0	
306	"	19	20.43·0	..	..	..	..	..	..	P.T. and A.T. small to moderate.
	"	20	..	23.21·0	23.25·5	..	3·0	23.32·0	..	
	"	21	..	..	..	..	..	..	11.56·0	
307	"	21	†21.40·0	..	..	..	..	..	..	Minute and small tremors.
	"	22	..	..	..	..	..	..	†23.55·0	
308	"	23	20.47·0	..	..	..	..	..	22.44·0	Very minute tremors.
309	"	24	..	..	2.01·0	..	?	..	..	Very small local shock.
310	"	25	..	..	22.17·0	..	?	..	..	"

[Note.—Record defective from 5th June to 9th June.]
† About.

Records of Milne Seismograph No. 20—*continued.*

No.	Date.		P.T. (from)	B.	Maxima.		Amp.	E.	A.T. (till)	Remarks.
					From	To				
	1902.						Mm.			
311	June	26	0.34·0	5.49·0	5.52·0	..	2·0	5.56·0	7.46·0	P.T. and A.T. mostly very minute. (Boom-period, 18 sec.)
312	„	26	19.41·0	..	..	..	..	..	..	Tremors at first minute; larger from 21.35 (28th June); several local shocks, the principal ones being those given. A.T. minute, gradually dying away.
	„	27	..	..	..	..	..	..	..	
	„	28	..	..	5.53·0	..	1·5	..	..	
	to		..	..	7.53·0	..	2·0	..	..	
			..	..	8.09·0	..	1·4	..	..	
	„	29	..	..	..	..	..	..	*11.30·0	
313	„	29	*16.45·0	..	..	..	..	..	..	Minute tremors, with several very small local shocks.
	„	30	..	..	..	..	..	..	*13.35·0	
314	„	30	..	..	22.30·3	..	?	..	..	Very small local shock.
315	July	1	..	..	5.40·5	..	1·0	5.46·5		
316	„	1	..	..	8.00·4	..	..	8.03·0	..	Small.
317	„	1	..	..	9.00·5	..	..	..	..	„
318	„	1	15.33·0	..	..	..	..	..	..	Tremors.
	„	2	..	..	..	..	..	..	11.14·0	
319	„	4	..	..	3.34·8	..	..	..	..	Small; ? local.
320	„	4	..	..	4.33·2	..	..	1.0	..	[EQ. at Montana, U.S.A.]
321	„	4	21.15·6	..	..	..	..	..	..	Tremors. [Destructive EQ. at Salonika, 5th July.]
	„	5	..	..	0.41·0	†3.23·0	2·0	..	..	
	„	6	..	..	..	..	..	..	*5.40·0	
322	„	6	7·23·0	..	7.39·8	..	5·0	..	..	? Local, or insect; followed by smaller shocks >>.
	„	6	..	..	..	7.49·6	8·4	..	..	
323	„	6	13.05·2	13.12·8	13.15·2	..	10·0	13.37·0	..	? Italy. (Boom-period, 18 sec.)
324	„	8	*8.30·0	..	..	..	..	..	*16.40·0	Very small tremors. [S.E. Australia.]
325	„	8	..	..	22.41·0	..	..	..	..	Very small.
326	„	11	*22.30·0	..	..	..	..	..	..	Small tremors. [Venezuela.] (Boom-period, 17·5 sec.)
	„	12	..	..	..	..	..	..	*8.10·0	

327	July	14	12.07·0	..	19.03·5	..	1·0	..	..	[EQQ. Italy, Turkey, Venezuela.]
	"	15	..	..	..	..	..	..	1.20·0	
328	Aug.	9	14 37·3	14.43·6	14.47·2	..	5·2	15.05·0	*16.00·0	Other tremors for two hours before. (Boom-period, 18 sec.)
329	"	13	19.12·0	..	..	..	..	..	..	Small tremors, with several small shocks.
	"	14	..	..	..	..	..	..	8.15·0	
330	"	16	8.11·6	8.19·5	8.22·5	..	9·0	8.28·3	9.03·6	[Tidal wave at Altata and other Mexican harbours.] (Boom-period, 17 sec.)
331	"	20	*22.00·0	..	..	..	..	..	..	Small tremors. [Philippines.]
	"	22	..	..	..	..	..	..	2.40·0	
332	"	22	3.29·0	4.06·5	4.23·9	4.27·5	8·0	..	..	After-tremors large. [Kashgar.]
	"	23	..	..	..	..	..	..	22.30·0	
	"	24	..	..	..	..	..	..	92.5·0	Smaller tremors.
333	Sept.	5	12.39·8	..	..	..	..	..	..	Tremors, many large.
	"	7	..	..	..	..	..	..	9.03·0	
334	"	9	..	..	22.57·0	..	..	..	..	Small shocks; probably local.
335	"	10	..	..	1.16·6	..	..	..	..	
336	"	10	..	..	8.02·6	..	..	..	..	
337	"	10	16.40·0	..	..	..	..	..	..	Small tremors.
	"	12	..	..	..	..	..	..	*6.50·0	
338	"	14	14.41·0	..	..	..	..	..	..	Tremors; very small to small.
	"	15	..	..	..	..	..	..	11·51·0	
339	"	16	2.01·5	..	2.03·4	..	2·0	..	2.27·5	[? Australia.]
340	"	17	7.40·0	..	..	..	..	..	10.21·0	Very small tremors. [? Australia.]
341	"	18	22.44·3	..	23.10·3	..	3·0	..	..	Other tremors and shocks before and after for many hours. (Boom-period, 15 sec.) [EQQ. in South Australia and San Francisco.]
342	"	19	..	..	9.18·2	..	..	..	..	
343	"	19	..	..	9.28·1	..	..	..	..	
344	"	19	..	..	9.30·9	..	..	..	..	
345	"	19	..	..	9.40·8	..	..	..	..	
346	"	19	..	..	9.46·8	..	..	..	..	
347	"	19	..	..	10.08·1	..	..	..	..	
348	"	19	..	..	10.34·0	..	..	..	..	
349	"	19	..	..	11.09·4	..	..	..	..	
350	"	19	..	..	12.08·5	..	..	..	..	

* About. † Large tremors.

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

No.	Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1902.					Mm.			
351	Sept. 21	0.50·4	1.07·0	1.08·0	..	1·4	1.14·5	*21.30·0	Preceded and followed by tremors and other small shocks till 21.30 (about).
352	„ 22	1.42·0	2.06·2	2.08·2	2.55·8	20·0	2.56·4	6.02·0	(Boom-period, 15 sec.) [Ecuador.]
353	„ 23	20.33·1	20.44·9 or 21.05·2	21.14·0	..	30·0	21.48·0	24.13·0	[EQ. in Central America and Mexico.]
354	„ 24	1.44·0	..	1.16·8	..	1·0	1.19·0		
355	„ 25	0.35·0	..	..	..	..	..	*18.30·0	Small tremors.
356	„ 28	15.12·5	15.15·8	15.19·0	..	2·0	15.25·0	..	(Boom-period, 18 sec.)
357	„ 28	20.42·4	..	20.43·0	..	..	..	..	Small; probably local.
358	„ 29	..	..	7.49·0	..	..	..	..	„ „
359	„ 29	19.01·0	..	21.54·2	..	2·8	..	..	After-tremors very large for thirty-six hours.
	Oct. 1	..	..	..	..	..	..	7.02·0	
360	„ 2	*14.35·0	..	..	..	..	..	..	Tremors, large from about 6.30 on 3rd October. (Boom-period, 17·9 sec.)
	„ 4	..	..	..	..	..	..	*9.21·0	
361	„ 4	..	..	18.16·0	..	..	..	..	Local shocks and tremors.
	„ 5	..	..	..	..	..	10.13·0	..	
362	„ 5	14.52·2	14.57·0	14.59·2	..	3·0	15.14·0		
363	„ 7	*3.00·0	..	..	..	..	..	..	Tremors, many large. [EQQ. in Australia.]
	„ 8	..	..	..	..	..	..	*10.00·0	
364	„ 8	18.23·0	..	..	..	..	..	..	
	„ 9	..	..	..	..	..	..	10.53·0	
365	„ 10	11.17·2	11.19·0	11.21·2	..	2·4	11.32·0	?	

366	Oct.	10	14.50·0	..	..	..	..	..	..	Tremors, many large.
	"	11	..	..	..	..	..	..	*16.20·0	
367	"	22	*20.00·0	..	..	..	..	..	..	Tremors, many large. [EQQ. at Perugia, &c.]
	"	23	..	..	..	..	..	..	*12.00·0	
368	"	23	*19.30·0	..	..	..	3·0	..	..	Tremors, many large. [Severe EQQ. in Guatemala; volcanic eruption at Sa. Maria.]
	"	24	..	..	..	..	..	..	18.20·0	
369	"	28	..	9.47·0	9.56·0	..	1·8	10.09·0		
370	"	29	..	..	20.27·0	..	..	..	..	Small.
371	"	31	22.18·0	..	22.41·0	..	..	..	..	Small, but distinct. [Volcanic activity, Sandwich Islands.]
372	Nov.	1	*18.00·0	..	..	..	..	..	..	Tremors, mostly small.
	"	2	..	..	..	..	..	..	*22.00·0	
373	"	4	*18.30·0	..	..	..	..	..	..	" " [EQQ. in Bosnia.]
	"	6	..	..	..	..	..	..	*3.10·0	
374	"	7	1.33·5	1.34·2	1.35·0	..	2·0	1.42·0	..	Followed by tremors, 10.30. [Volcanic eruption, Sandwich Islands.]
375	"	7	*19.00·0	..	..	..	..	..	..	Tremors, mostly small.
	"	8	..	..	..	..	..	..	*5.30·0	
376	"	8	*14.00·0	..	..	..	..	..	..	" "
	"	9	..	..	..	..	..	..	*12.00·0	
377	"	9	*14.00·0	..	..	..	..	..	..	" "
	"	10	..	..	..	..	..	..	*7.00·0	
378	"	11	1.05·0	..	..	..	..	..	?	Tremors.
	"	11	3.31·0	3.52·0	3.53·0	..	3·0	..	..	Shock, with long after-tremors.
	"	12	..	..	..	..	..	..	*7.10·0	
379	"	12–15	23.11·0	..	..	..	4·0	..	12.00·0	Tremors, many very large.
380	"	20	20.06·5 or 20.17·5 or 20.37·0	20.41·0	20.44·2	..	20·0	?	..	Shock; followed by tremors and repeats till 9.45 on 21st November. ? Algeria.
	"	21	..	..	..	..	..	..	*9.45·0	
381	"	25	*19.40·0	..	..	..	..	..	..	Tremors.
	"	26	..	..	..	..	..	..	*21.00·0	

* About.

RECORDS OF MILNE SEISMOGRAPH No. 20—*continued.*

No.	Date.	P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	Remarks.
	1902.					Mm.			
382	Nov. 27	17.42·0	..	21.19·8	..	3·2	..	..	Tremors. (Boom-period, 18·6 secs.) [Vol-
	to 29	..	..	..	..	..	..	5.05·0	canic eruption in St. Vincent.]
383	Nov. 29 to	*22.30·0	..	..	..	2·8	..		
	Dec. 1	..	..	..	..	..	..	9.13·0	Tremors, many large.
384	Dec. 12	23.55·0	..	23.59·5	..	4·6	..		
	" 13	..	..	..	..	..	0.38·2	7.46·5	[EQ. in Denmark.]
385	" 14	4.32·0	..	..	..	..	..	16.13·0	Small tremors.
386	" 14	20.39·0	..	..	..	..	..	..	Tremors, moderate.
	" 15	..	..	..	..	..	..	7·30·0	
387	" 16	12.52·2	..	..	..	..	..	..	Tremors, small. [Destructive EQ. in Turke-
	" 17	..	..	..	..	..	..	1.51·4	stan.]
388	" 27	..	..	22.14·0	..	..	..	..	Local, small.
389	" 27	20.48·0	..	..	..	..	..	..	Tremors, moderate.
	" 28	..	..	..	..	..	..	12.04·0	
390	" 28	19.08·0	..	..	..	..	..	..	Tremors, many large; many shocks (? local).
	" 29	..	..	..	..	..	..	7.36·0	
391	" 29	23.38·5	..	..	..	..	..	..	Small tremors.
	" 30	..	..	..	..	..	..	1.02·8	

* About.

N.B.—"Local" applied to shocks in this list implies that the origin was in or near New Zealand. 1 millimeter of amplitude = 0·51 seconds of arc or angle of tilting of the east and west line.

Records of Milne Seismograph No. 16, at Christchurch, New Zealand.

Latitude, 43° 31′ 50″ S.; longitude, 172° 37′ 18″ E. Time employed: Greenwich mean civil time.

P.T., preliminary tremors less than 2 mm. complete amplitude; A.T., after-tremors less than 2 mm. complete amplitude; B., E., beginning and end of vibrations not less than 2 mm.; Amp., half-range in millimetres; 1 mm. boom motion = 0″.43. B. and E. signify beginning and end of amplitudes exceeding 1 mm., the range being 2 mm.

C. Coleridge Farr, Observer.

Date.	P.T. (from)	B.	Maxima.		Amp.	E.	A.T. (till)	B.P.	Remarks.
			From	To					
1902.					Mm.			Secs.	
Jan. 1	05.44·5	06.09·7	06.16·0	..	5·1	06.23·0	08.40·0	20	
" 2	..	..	15.04·5	15.07·3	1·0	..	..	..	Very sharp tremor.
" 8	23.59·7	..	00.07·7	..	1·1	..	06.47·0	18	Magnetographs much affected from 11 h. 00 m. to 11 h. 39 m.
" 12	22.39·5	23.05·47	23.08·0	..	2·6	23.10·0	00.07·0	18	
" 15	06.30·2	..	06.36·5	..	0·4	..	06.42·0	18	
" 17	06.18·5	..	06.46·8	..	0·4	..	07.18·0	18	
" 18	23.49·3	..	00.09·7	00.28·3	0·3	..	12.39·0	18	
" 21	10.13·0	..	10.22·3	..	0·6	..	10.35·5	18	
" 21	22.32·3	..	22.41·5	..	0·4	..	23.02·0	18	
" 22	06.17·0	..	06.23·0	..	0·3	..	06.28·2	18	
" 24	..	..	10.06·5	..	0·5	..	..	18	Very sharp tremor.
" 24	23.34·7	23.39·7	23.48·6	..	16·7	..	..	18	The largest "shock" recorded to this date, but not felt personally.
			23.49·5	23.51·5	17·0+				
				23.55·6	7·5				
				23.57·8	5·2	23.49·1	27.30·0		
" 26	04.30·7	..	04.36·6	..	0·7	..	04.43·0		
" 26	05.34·0	..	05.36·0	05.41·0	0·3	..	05.44·0	18	
" 28	07.26·0	..	07.28·0	..	0·3	..	..	18	

RECORDS OF MILNE SEISMOGRAPH No. 16—*continued.*

Date		P.T. (from)	B	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	B.P.	Remarks.
1902.						Mm.			Secs.	
Jan.	30	14.23·2	14.50·8	15.01·5	15.03·0	2·0	15.08·2	16.00·0	18	
Feb.	3	23.34·8	23.48·7	23.50·6	..	3·2	..	..	18	
				23.53·4	..	1·8				
				23.55·4	..	1·9				
					23.56·5	1·8	00.01·7	00.03·0		
	9	07.40·8	07.45·9	07.49·9	07.52·0	17·0	08.30·5	Indef.	18	
	9	Indef.	10.15·9	10.20·0	10.22·3	17·0	11.12·9	11.21·0	18	
	10	08.25·9	08.29·8	08.30·3	..	1·2	08.31·6	08.43·2	18	
	10	22.21·8	..	22.23·0	.	0.2		22.26·8	18	
	11	00.56·3	..	01.10·6	..	0·5	..	01.19·9	18	
	11	02.10·0	.	02.12·8	..	0·9	..	02.28·0	18	
	13	10.59·7	.	11.09·7	..	0·3	..	10.55·9	18	
	17	00.54·8	01.24·4	01.31·5	..	1·1	01.35·2	03.11·0	18	
	24	01.38·0	..	01.39·7	..	0·1	..	01.54·5	18	
	26	13.34·6	.	13.39·2	..	0·3	.	13.45·3	18	Isolated tremor.
Mar.	1	00.34·6	..	01.05·2		0·2	..	01.30·0	18	
	3	10.51·7	..	11.00·4	..	0·8	.	Indef.	18	Slight tremor; storm afterwards.
	5	19.31·2	19.47·6	19.51·6	..	2·9	19.57·2	20.38·4	18	
	10	04.37·8	..	04.53·8		0·2	..	05.38·6	18	
	12	15.15·0	15.15·5	15.20·2	..	4·7	..	..	18	
				15.24·2		4·5				
				15.25·2	..	4·0	15.35·4	15.59·7		
	22	23.14·0	.	23.31·8	..	0·8	..	..	17	
	23	01.34·3	.	01.39·8	..	0·5	..	01.56·3	17	
	25	04.25·7	..	04.28·3	.	0·1	..	04.48·5	17	

Mar.	28	05.46·8	..	05.47·4	05.49·3	0·6	..	06.06·2	17	
„	28	09.42·0	..	10.03·5	..	1·0	..	10.37·2	17	
„	28	14.53·8	15.03·4	15.23·3	..	4·2				
				15.24·7	..	4·0				
				15.29·2	..	3·1	15.38·7	18.11·0	17	
„	31	..	..	16.08·5	..	0·8	..	Indef.	17	
April	1	..	..	09.11·0	..	0·2	..	„		
				09.12·7	..	0·2				
„	6	06.53·2	..	06.58·0	..	0·3	..	07.05·0		
„	7	02.31·0	..	02.34·2	..	0·3	..	02.54·0	16	
„	7	05.39·0	..	05.52·2	..	1·0	..	06.43·7	16	
„	7	08.02·2	..	08.07·5	..	0·2	..	Indef.	16	
„	9	Indef.	..	08.08·7	..	0·9	..	„	16	
„	10	14.43·7	..	14.51·0	..	0·2				
„	13	04.53·0	..	04.59·0	..	0·1	..	05.10·0	16	
„	14	22.24·7	..	22.37·5	..	0·1	..	22.43·0		
„	14	23.33·5	..	23.38·2	..	0·2	..	23.46·0	16	
„	17	17.22·0	..	17.24·0	..	0·1	..	17.30·0	16	
„	19	02.37·2	02.48·0	03.15·2	..	8·6	..	..	..	Origin Guatemala.
				03.19·2	..	12·0	04.21·0	05.56·0		
„	20	21.42·0	21.44·0	21.45·0	..	1·3	..	..	16	
				21.47·0	..	1·4	21.47·5	22.30·0	16	
„	21	15.10·0	..	15.31·0	..	0·2	..	15.46·5	16	
„	21	Indef.	..	18.02·0	..	1·0	..	Indef.	16	
„	22	10.48·0	..	10.50·5	..	0·1	..	..	16	
				10.55·2	..	0·1	..	11.02·5	16	
„	25	11.44·0	..	12.05·0	..	0·1	..	12.16·7	16	
„	27	..	..	04.52·7	..	0·4	..	..	16	Sudden tremor.
„	27	..	..	05.30·0	..	0·1	..	05.33·0	16	
„	28	..	..	18.15·2	..	0·4	..	..	16	Tremor, storm in progress.
May	2	11.55·0	..	12.17·7	..	0·2	..	13.01·0	16·7	
				12.31·0	..	0·1	..	..	16·7	
„	5	06.00·0	..	06.02·2	..	0·4	..	06.12·5	16·7	
„	7	03.43·0	..	03.49·2	..	0·1	..	03.53·0	16·7	
„	7	..	..	06.16·0	..	0·1	..	..	16·7	

RECORDS OF MILNE SEISMOGRAPH No. 16—*continued.*

Date.		P.T. (from)	B.	Maxima. From	Maxima. To	Amp.	E.	A.T. (till)	B.P.	Remarks.
1902.						Mm.			Secs.	
May	8	02.55·0	..	03.12·0	..	0·2	..	03.40·0	16·7	
〃	8	13.27·0	..	13.27·7	..	0·6	..	13.31·0		
〃	21	12.53·5	..	12.54·0	..	0·1				
				12.56·2	..	0·1	..	13.02·2	16·7	
〃	25	00.09·5	..	00.14·0	..	0·1	..	00.16·5		
〃	31	05·08·7	..	05.20·0	..	0·2	..	05.27·2	16·7	
〃	31	07·09·7	..	07.12·2	..	0·5				
				07.18·2	..	0·6	..	07.41·9	16·7	
June	7	20.40·5	..	21.32·0	..	0·2	..	22.13·0	16	
				21.48·2	..	0·2				
〃	10	03·37·2	..	03.46·0	..	0·3	..	03.58·2	16	
〃	18	00.17·2	..	00.28·2	..	0·2	..	00.52·9	16	
〃	19	05.06·7	05.09·5	05.10·0	..	1·6	..	05.33·2	16	
〃	19	12.28·0	12.30·7	12.31·0	..	1·9	..	13.03·7	16	
〃	21	06.51·5	..	06.59·0	..	0·7	..	..	16	
〃	22	02·02·2	..	02.08·2	..	0·5	..	02.20·2	16	
〃	26	05.23·5	..	05.51·2	..	0·6	..	06.31·0	16	
July	6	07.28·0	..	07.32·0	..	0·3	..	07.37·0	16	Elongated swelling.
〃	6	08.49·0	..	08.55·0	..	0·2	..	09.12·0	16·6	〃
〃	6	13.07·8	13.15·0	13.18·0	..	7·0				
				13.33·0	..	3·0				
				13.36·5	..	3·2	..	..	16·6	A.T. obscured by N.T.
〃	7	02.39·5	..	02.45·6	..	0·5	..	03·30 ±		
Aug.	2	..	..	22.51·8	..	3·0	..	..	..	Origin Suva? Beginning and end obscured by N.T.
				22.56·0	..	2·5				

Aug.	3	..	..	20.12·0	..	..	..	..	..	Swelling.
"	9	..	..	14.44·3	..	2·1	..	..	..	Sudden. P.T. and A.T. obscured.
				14.46·4	..	2·1				
"	13	04.54·6		..	..	0·3	..	05.04·2	..	Elongated swelling.
"	16	08.11·8	08.24·0	08.25·6	..	8·0	08.36·3			
				08.27·1	..	7·2	..	10.08·8		
"	22	03.20·8	03.41·2	04.20·3	..	3·5				
				04.21·9	..	4·0	..	07.14·8	16·6	Kashgar.
					04.34·6					
Sept.	10	02.07 9	..	..	..	..	..	12.11·9	..	Cheviot.
"	11	03.00·6	..	..	..	..	..	03.20·4	..	Elongated swelling.
"	22	01.57·3	02.02·0	02.06·4	02.33·7	14·3	02.52·3	06.00·3	16·6	
"	23	?	20·44·7	21.07·6	21.28·3	18·0	21.51·6	25.03·4	16·6	
"	24	05.31·5	..	..	..	0·5	..	05.56·9	..	Look like repetitions; similar elongated swellings.
"	24	08.25·2	..	..	..	0·8	..	08.50·7	..	
"	24	10.50·7	..	..	..	0·2	..	11.02·7	..	
Oct.	12	08.33·6	..	..	..	0·4	..	08.53·0	..	Elongated swelling.
"	28	09·54·2	..	10·16·0	..	1·1	..	?		
Nov.	13	10.31·6	..	10·32·5	..	0·2	..	?		
"	20	20.31·8	20.35·5	10.42·0	..	6·5	20.49·3	22.33·7		
"	21	07.23·6	..	..	..	..	..	08.49·3	..	Prolonged, but slight.
Dec.	25*	05.32·7	05.36·8	05.39·3	..	1·7	05.41·9	06.33·0		

* Not in operation from 1st to 25th.

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1873.

Cambridge, The Rev. O. Pickard, M.A., C.M.Z.S., Bloxworth Vicarage, Wareham, Dorsetshire.

Günther, A., M.D., M.A., Ph.D., F.R.S., Litchfield Road, Kew Gardens, Surrey.

1874.

McLachlan, Robert, F.L.S., care of Linnean Society, London.

Newton, Alfred, F.R.S., Cambridge, England.

1875.

Sclater, Philip Lutley, M.A., Ph.D., F.R.S., Zoological Society, London.

1876.

Etheridge, Prof. Robert, F.R.S., British Museum, London.

Berggren, Dr. S., Lund, Sweden.

1877.

Sharp, Dr. D., University Museum, Cambridge.

1883.

Lord Kelvin, P.C., G.C.V.O., D.C.L., F.R.S., care of Royal Society, London.

Ellery, Robert L. J., F.R.S., Observatory, Melbourne.

1885.

Sharp, Richard Bowdler, M.A., F.L.S.

Wallace, A. R., F.L.S., Broadstone, Wideborne, England.

1890.

Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden.

Liversidge, Professor A., M.A., F.R.S., Sydney.

1891.

Goodale, Professor G. L., M.D., LL.D., Harvard University, Massachusetts, U.S.A.

1894.

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Codrington, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

1895.

Mitten, William, F.L.S., care of Linnean Society, London.

1896.

Lydekker, Richard, B.A., F.R.S., British Museum, South Kensington.

Langley, S. P., Smithsonian Institution, Washington, D.C.

1900.

AGARDH, Dr. J. G., University of Lund, Sweden.

AVEBURY, Lord, P.C., F.R.S., High Elms, Farnborough, Kent.

MASSEE, GEORGE, F.L.S., F.R.M.S.

1901.

EVE, H. W., M.A., 37, Gordon Square, London.

HOWES, G. B., LL.D., F.R.S., Royal College of Science, South Kensington.

GOEBEL, Dr. CARL, University of Munich.

1902.

Professor G. O. SARS, University of Christiania, Norway.

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Holmes, R. L., F.R. Met. Soc., Fiji*
Holmes, R. T., Masterton
Hosking, Dr. A., Masterton
Hudson, G. V., F.E.S.
Hustwick, T. H.
Inwood, D., Canterbury
Jenkins, Digby A.
Johnson, G. Randall*
Joynt, J. W., M.A.
Keys, B.
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Krull, F. A., Wanganui
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Lee, H. M.
Lewis, J. H., Otago
Liffiton, E. N., Wanganui
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Geological Survey of Sweden, Stockholm.
University of Christiania, Norway.
Bergen Museum, Norway.
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Natural History Society of Copenhagen.
Dr. Lutkin, Copenhagen.
M. Teyler, Haarlem.
Academia Nacional de Ciencias de la Republica Argentina.
School of Mines, Rio de Janeiro.
Society of Engineers, Rio de Janeiro.
Zoological Society of Brazil, Rocha.
Musen Paulista, San Paulo, Brazil.
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Executive Library.
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Library, Auckland Institute.
Library, Hawke's Bay Philosophical Institute.
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Assistant Editor.
Draughtsman.
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Government Printer.
Photo-lithographer

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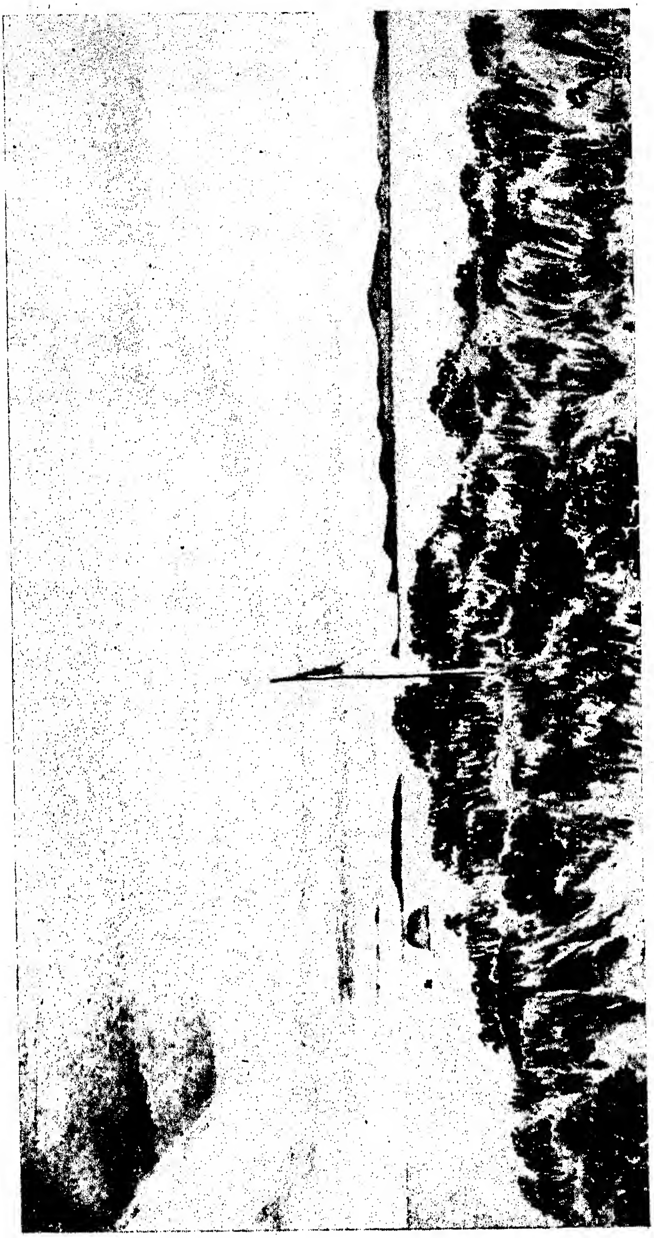

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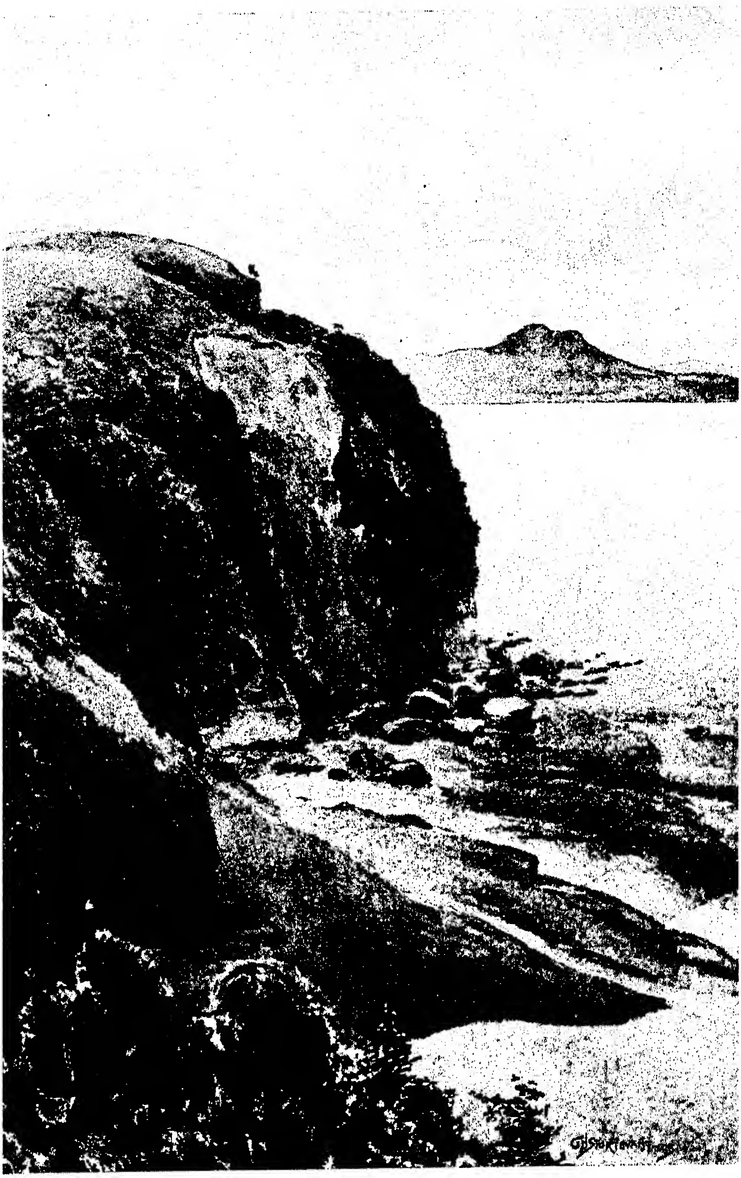

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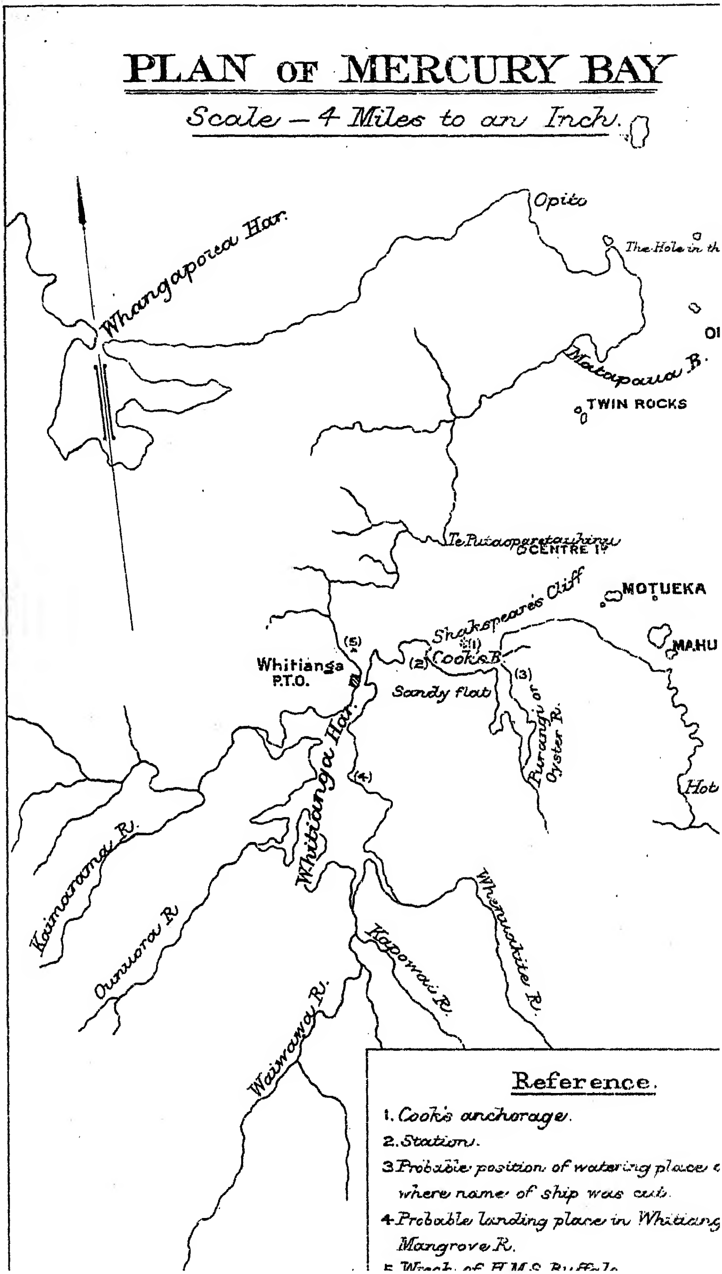
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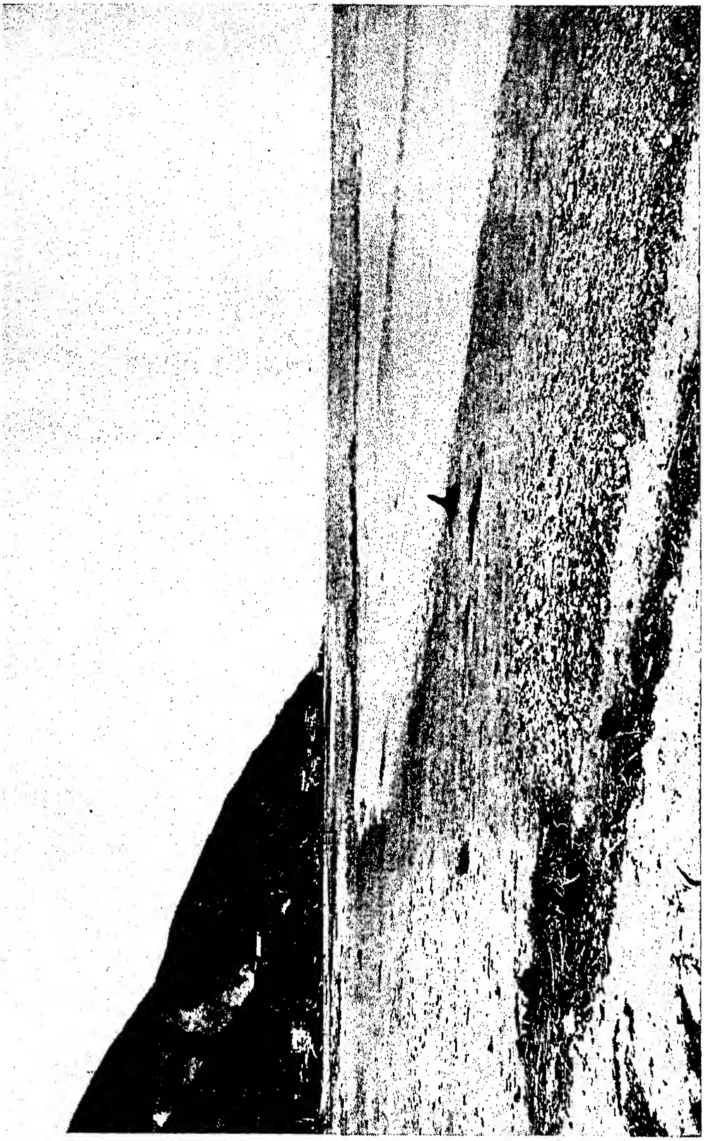

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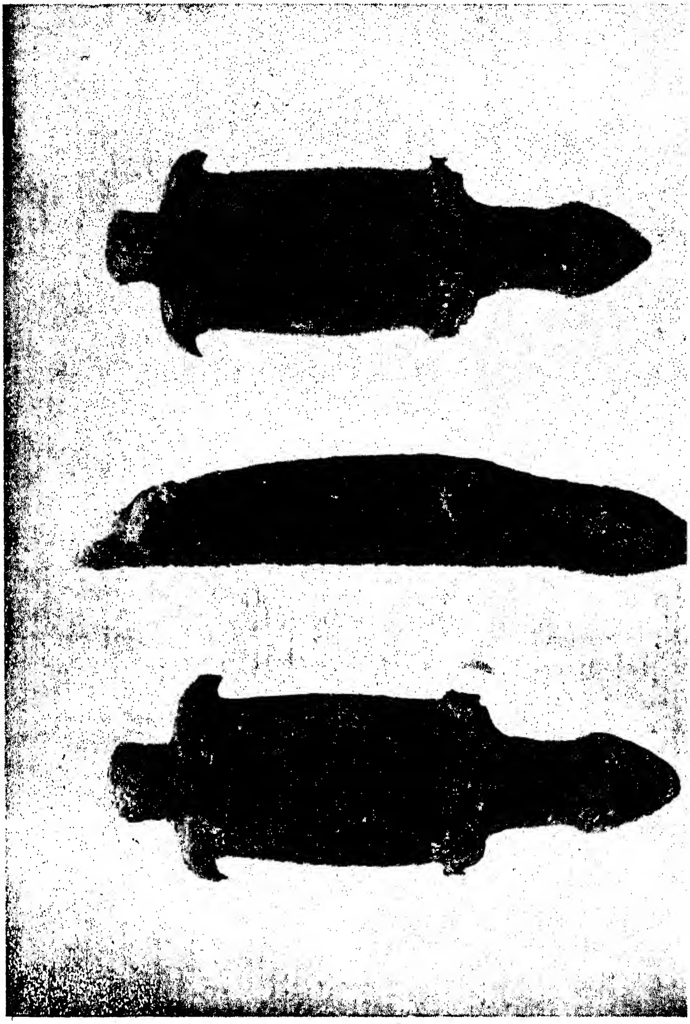

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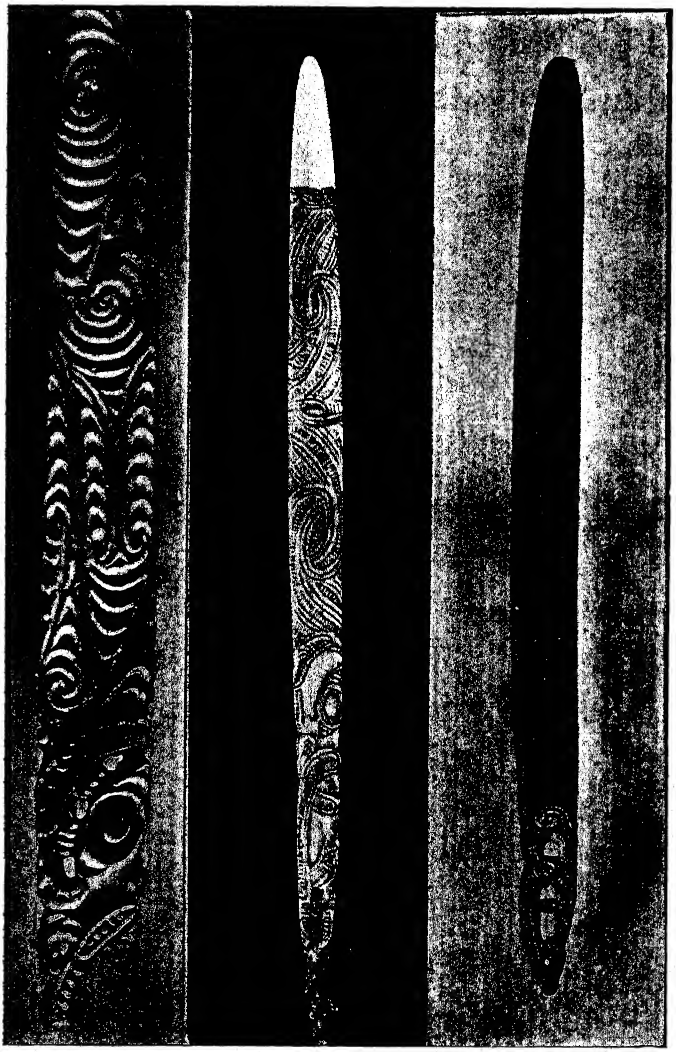

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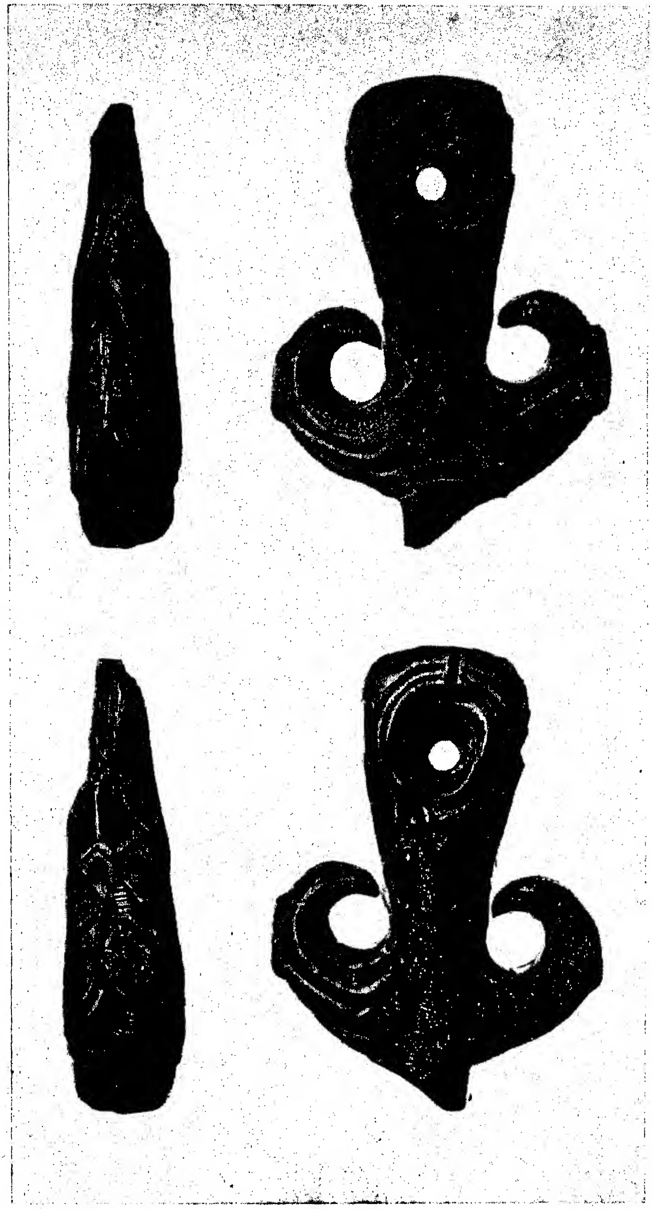

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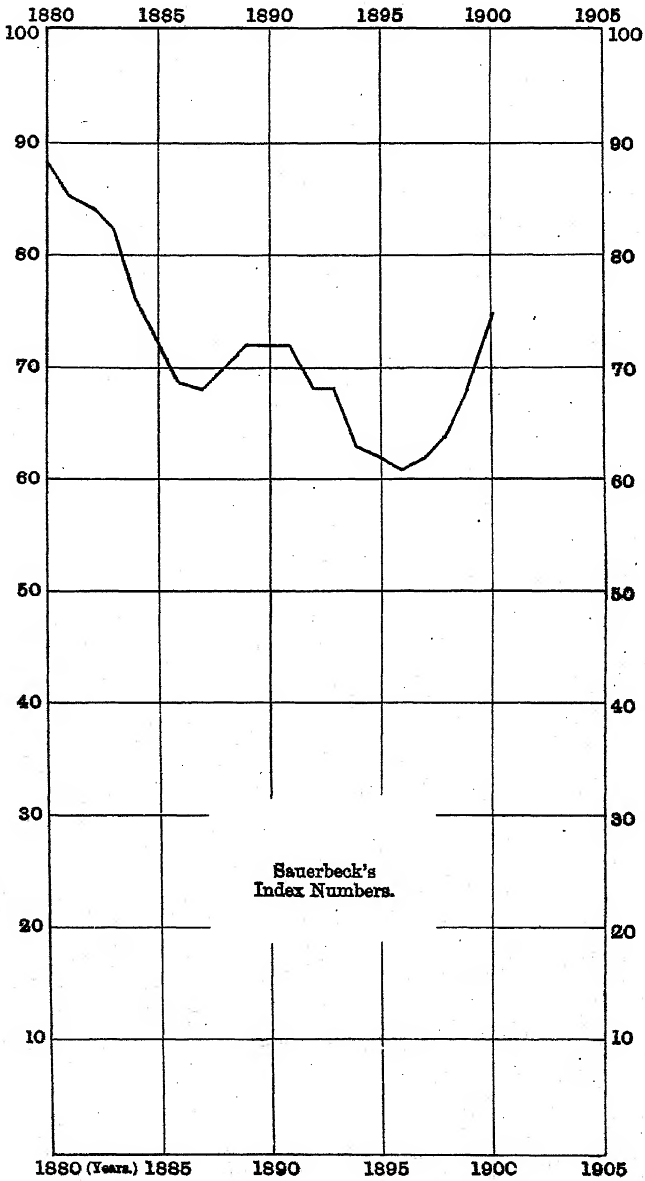

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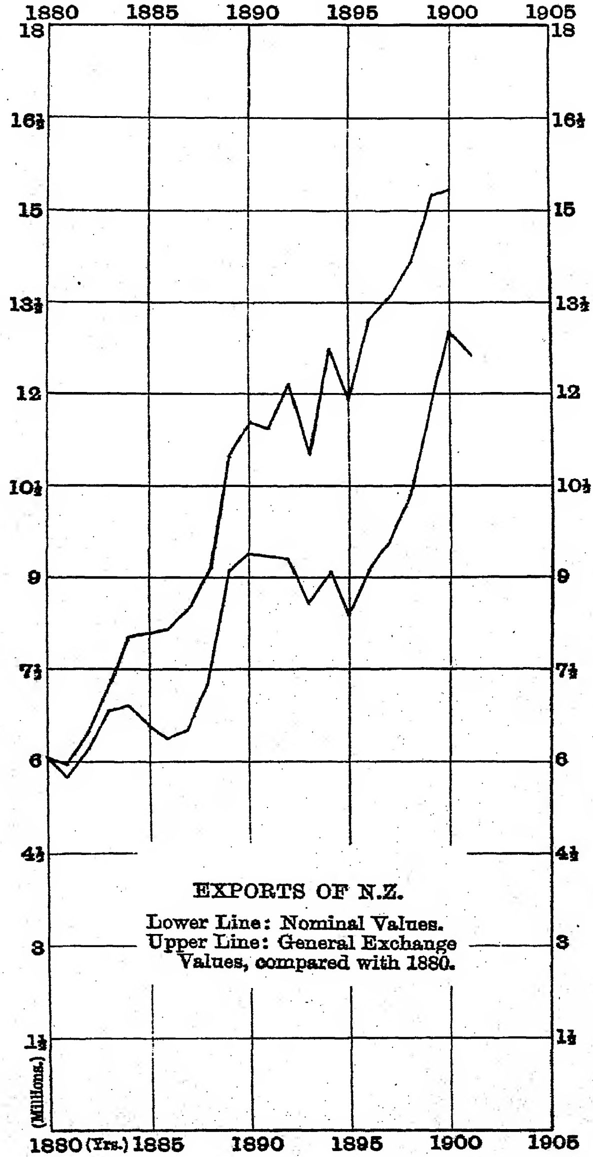

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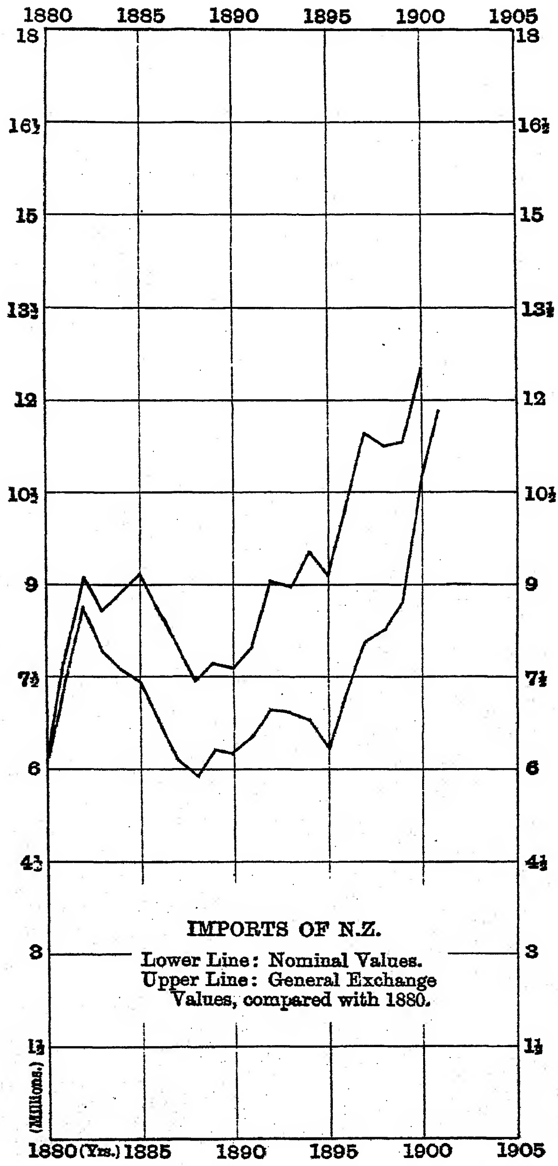

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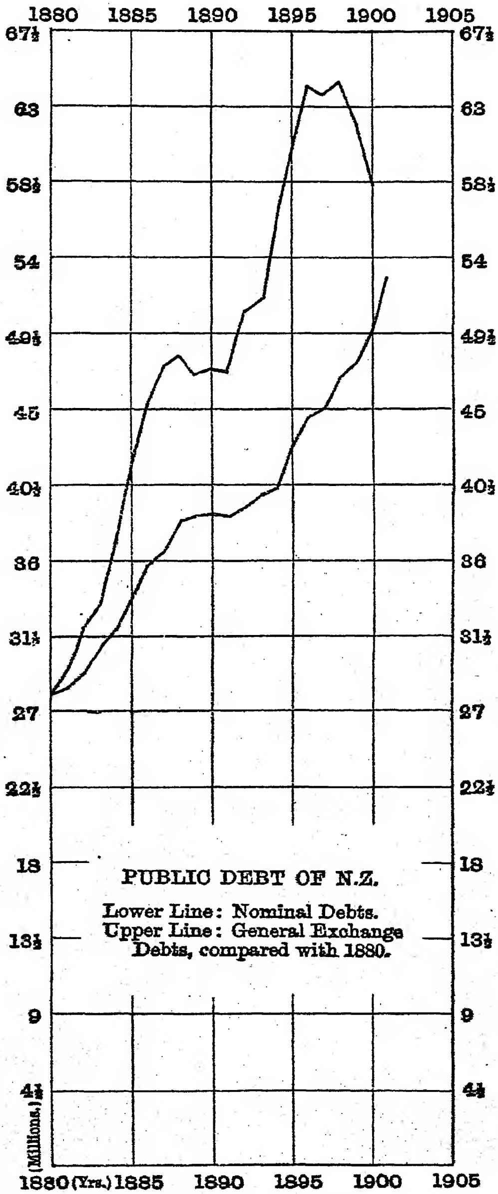

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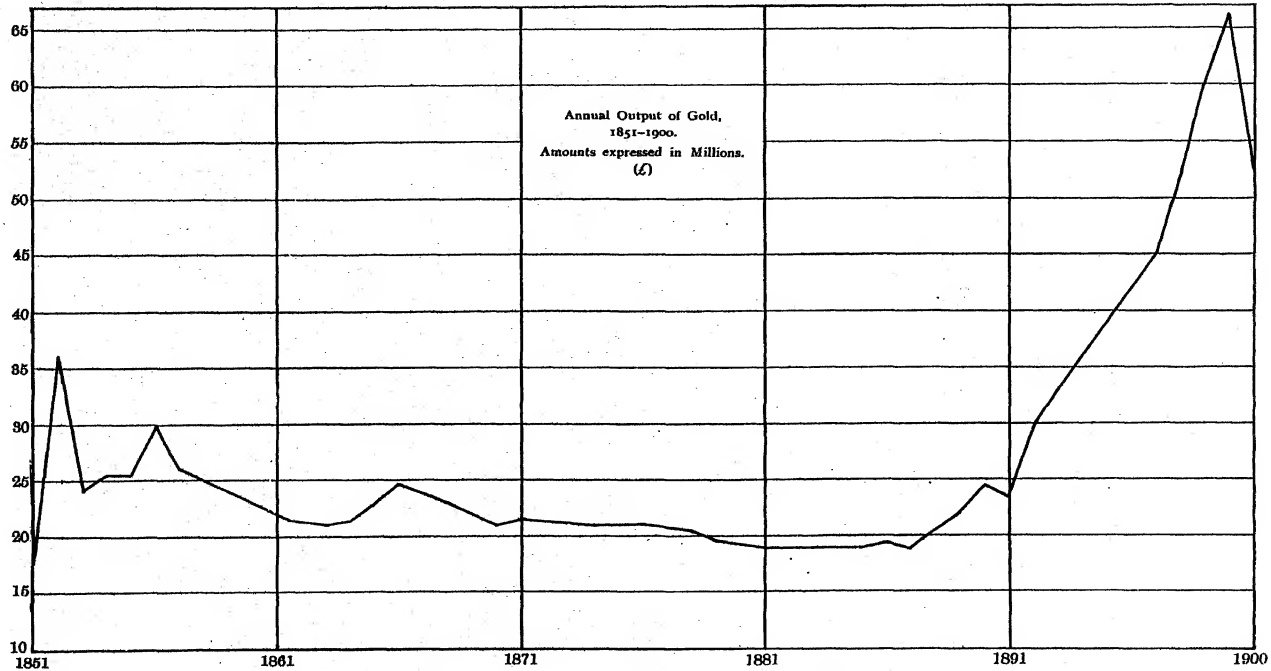

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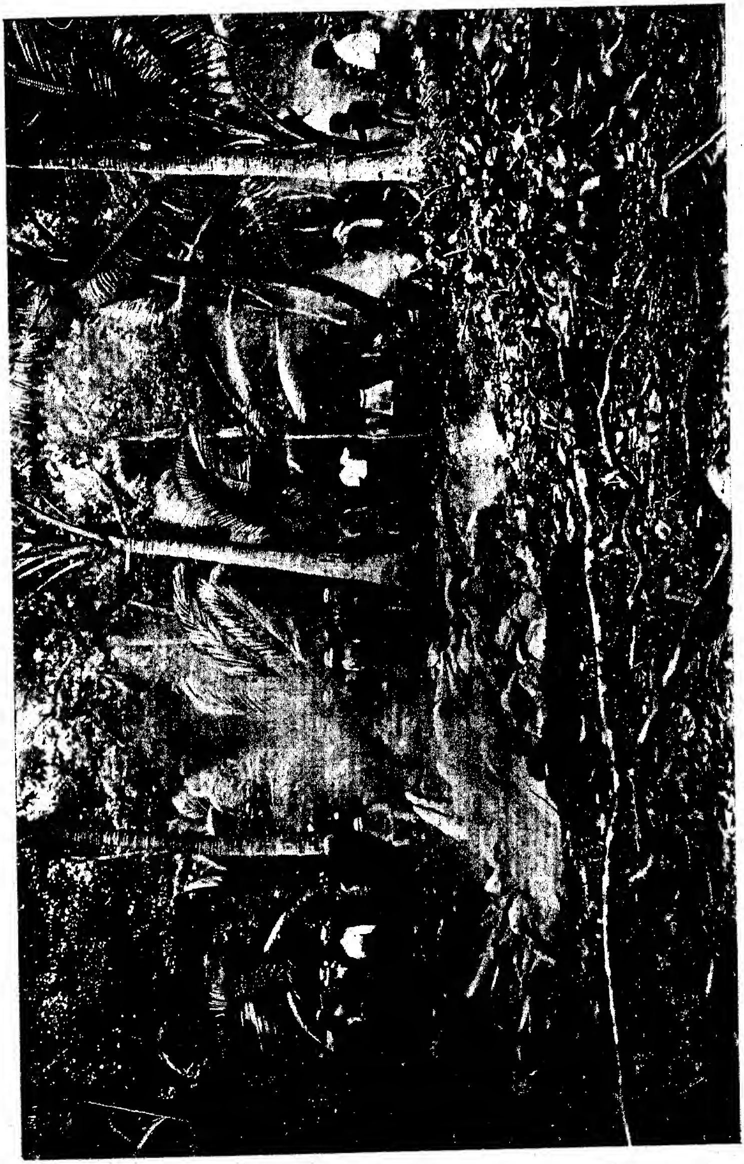

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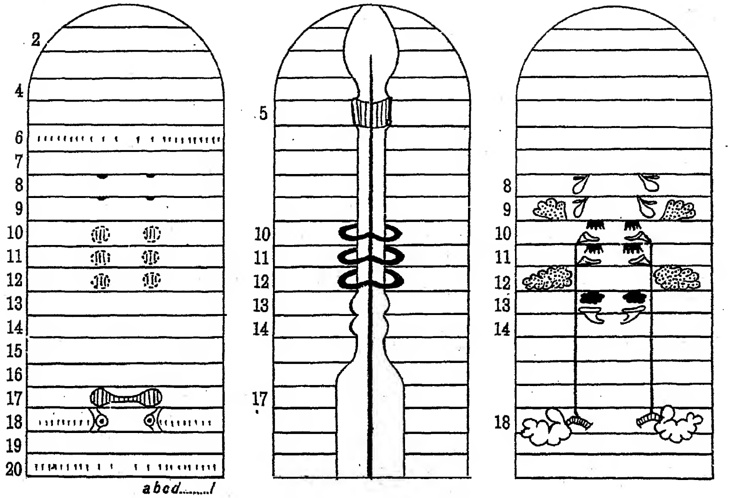

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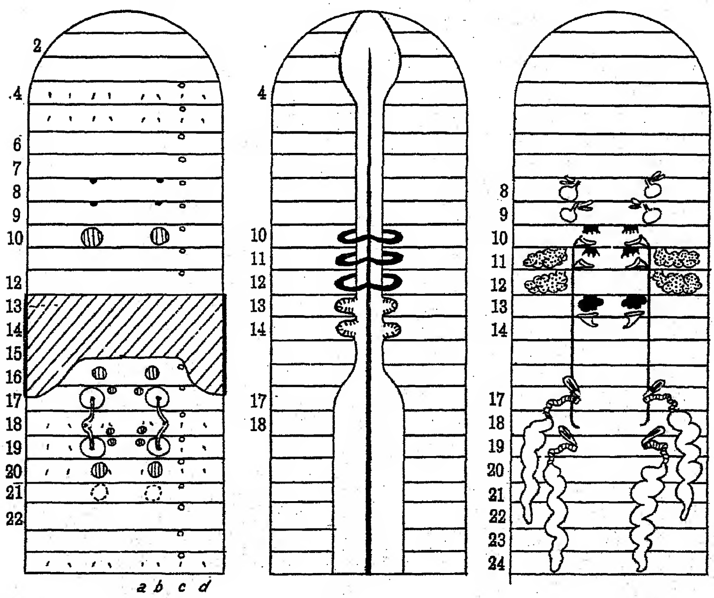

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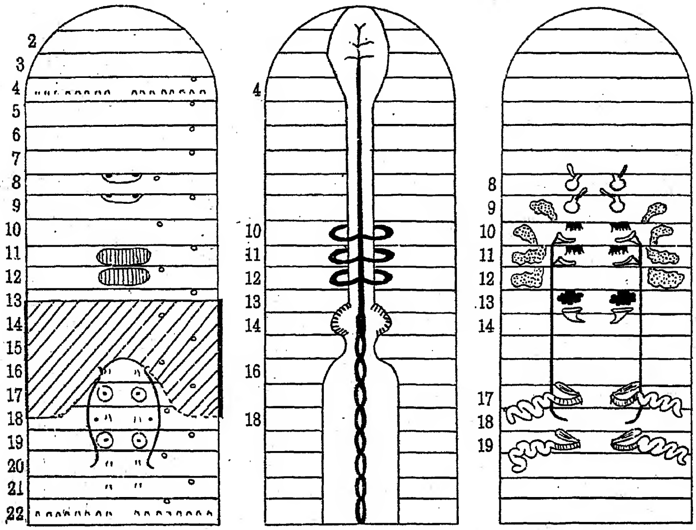

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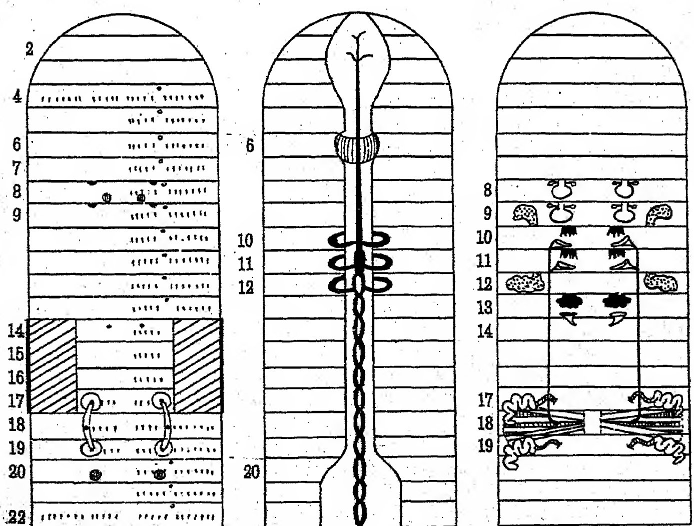

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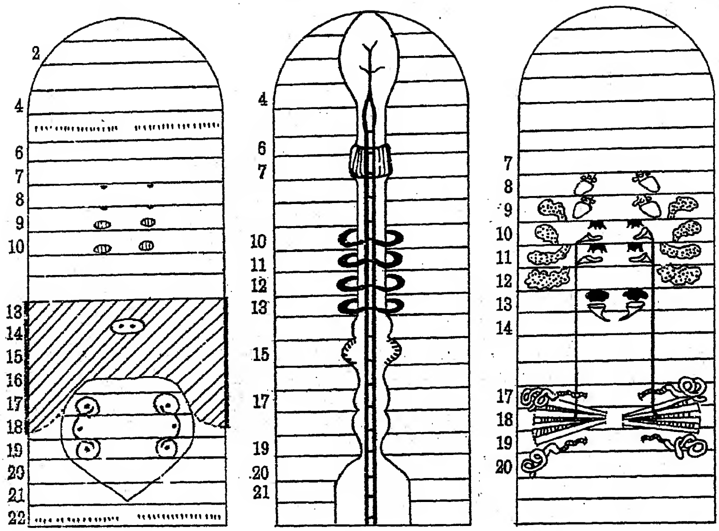

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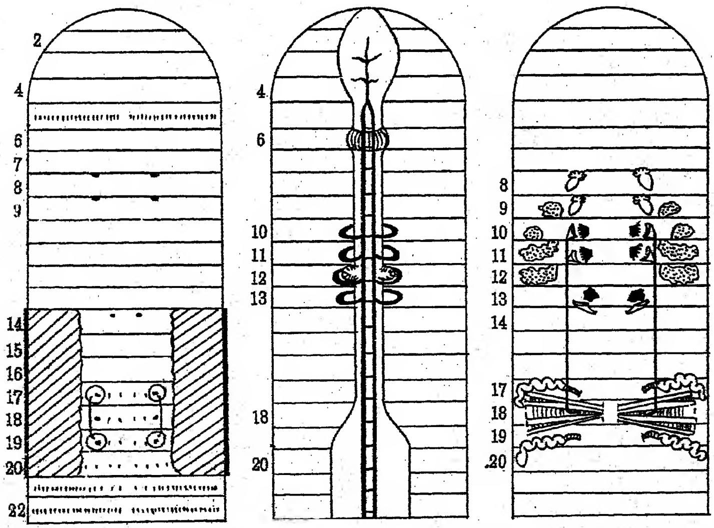

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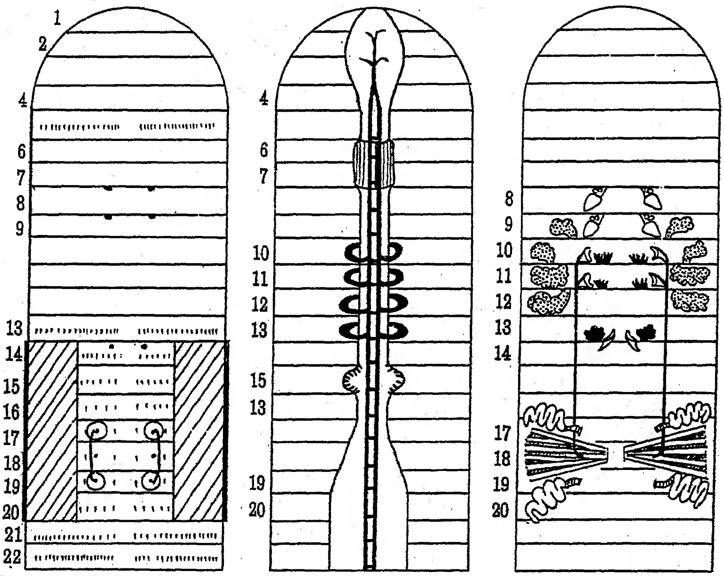

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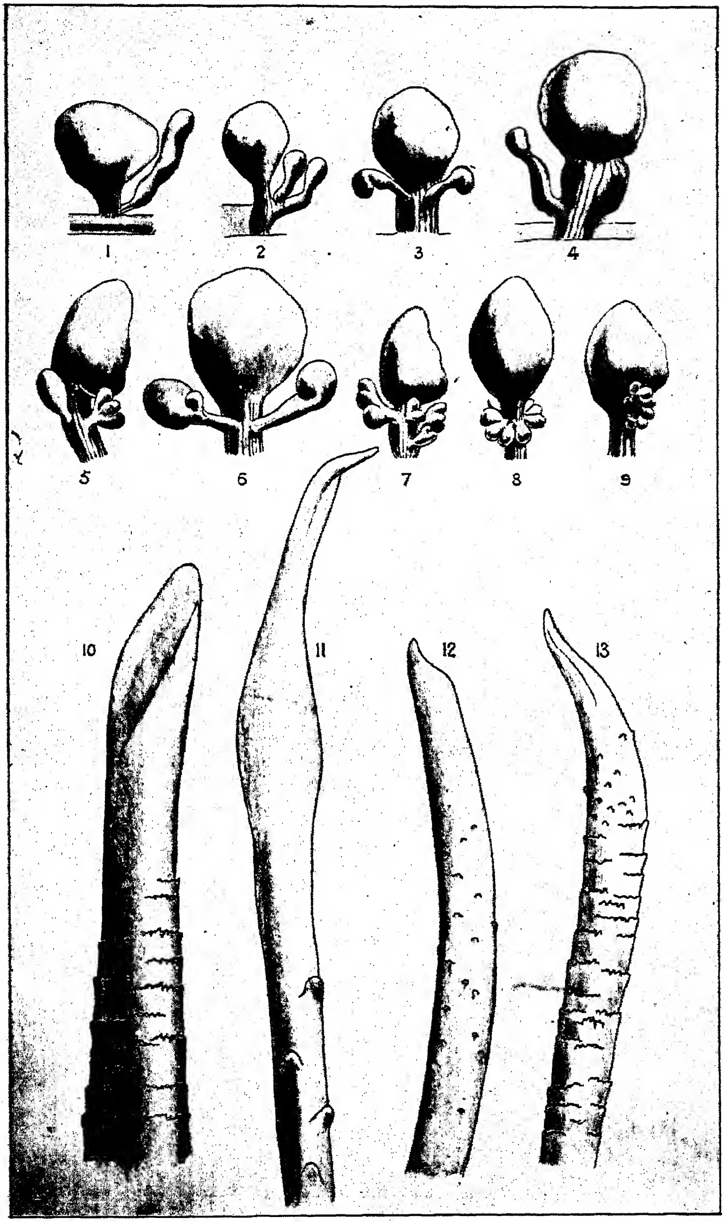

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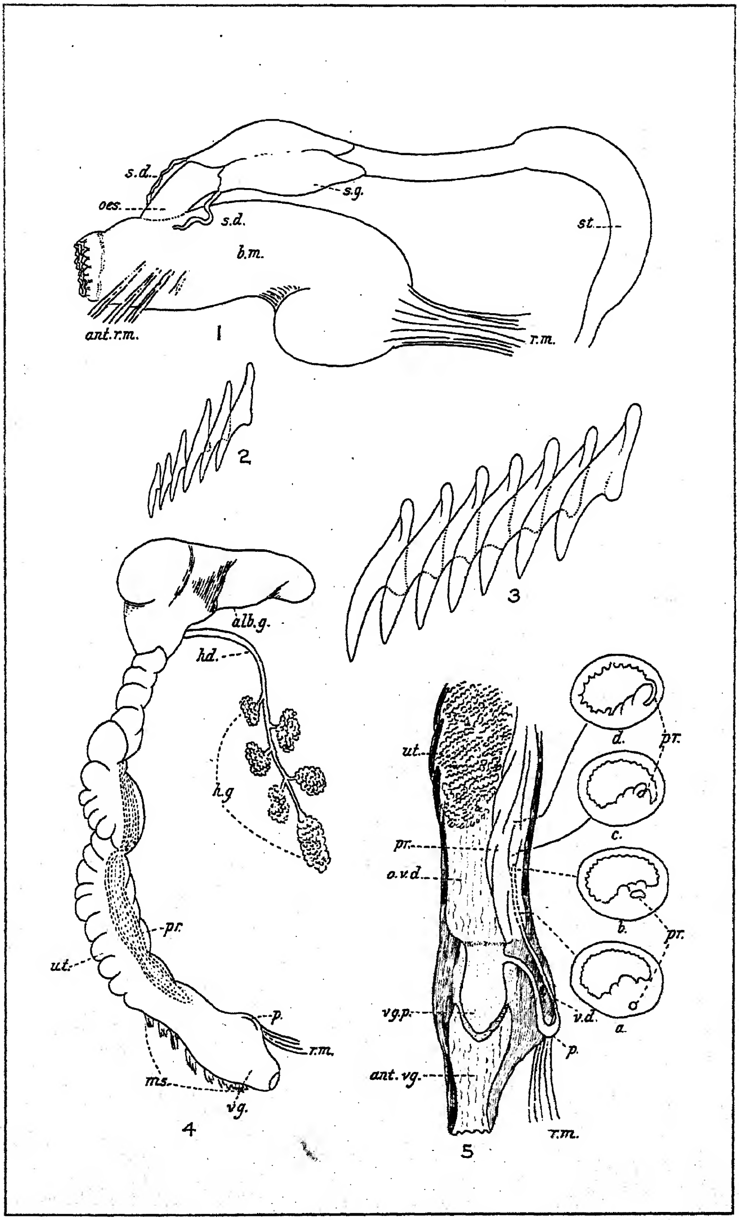

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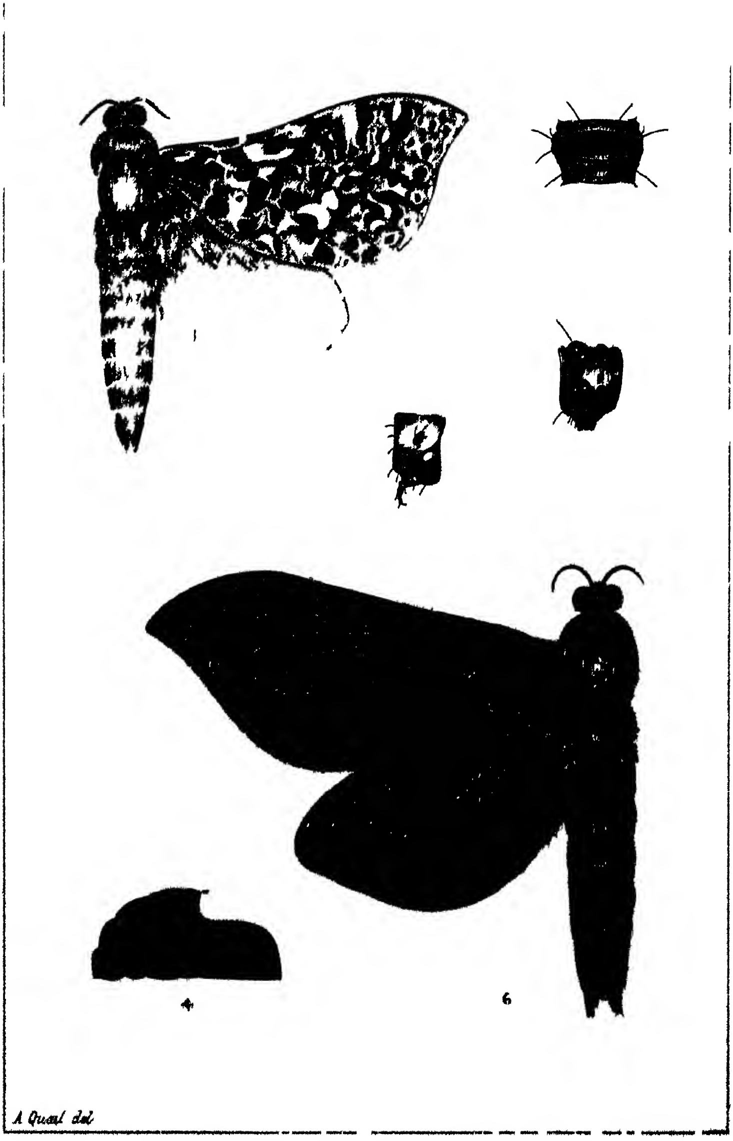

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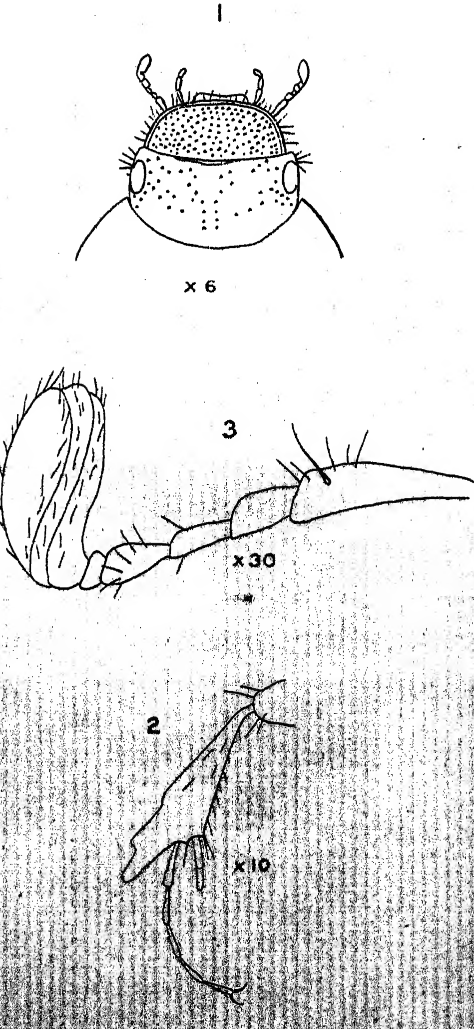

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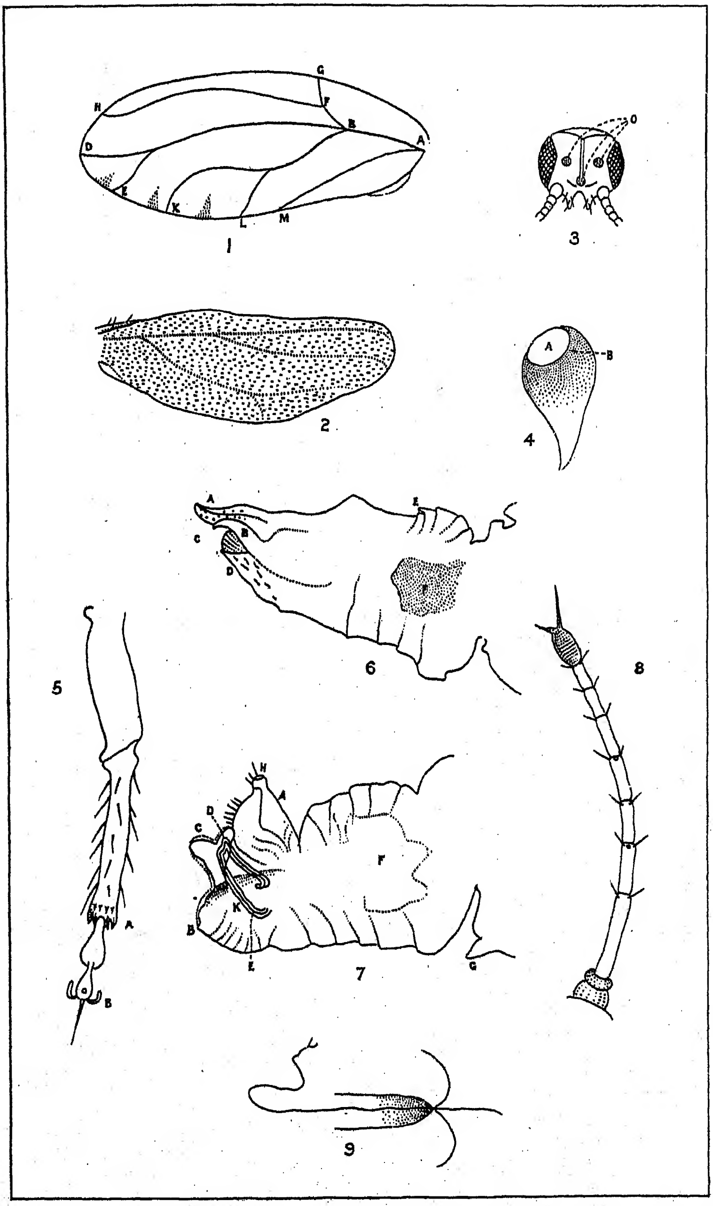

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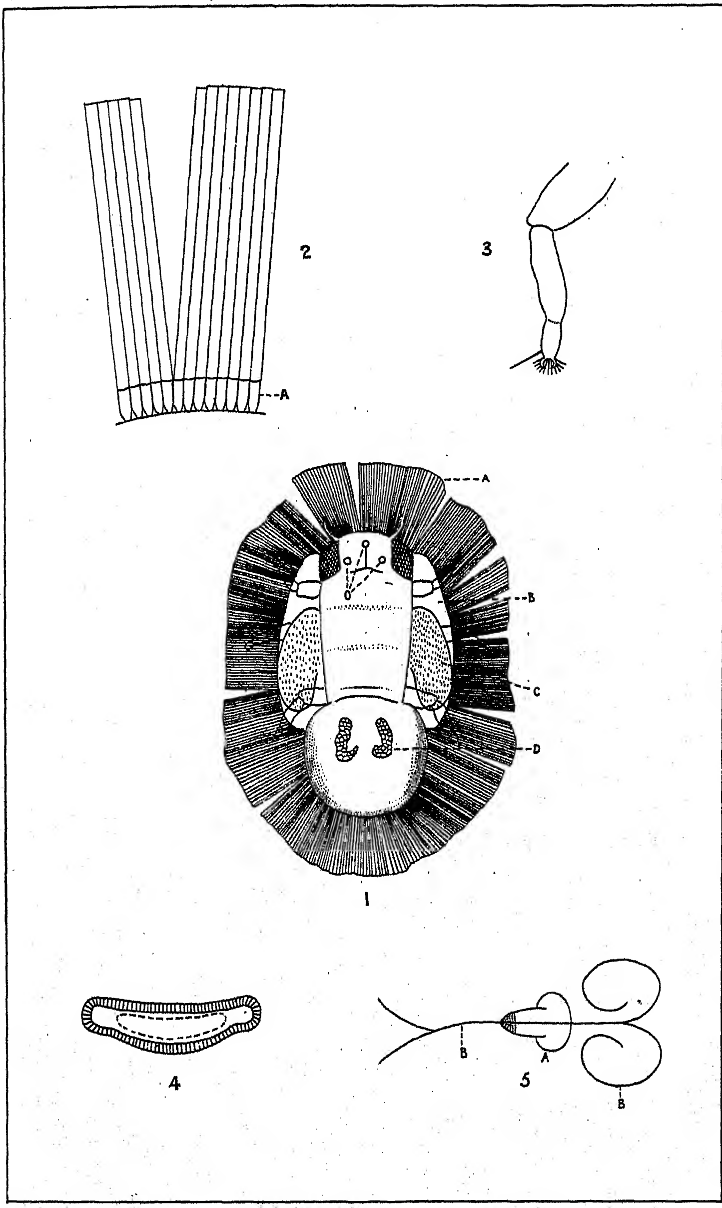

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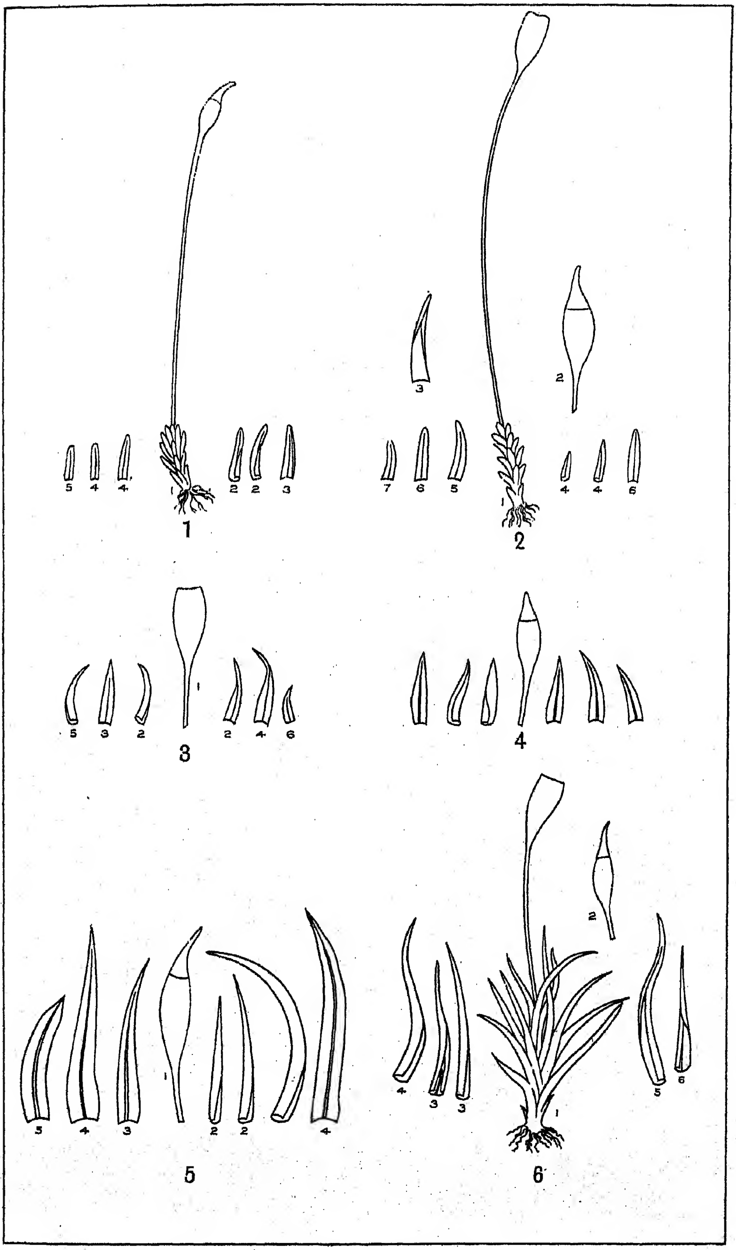

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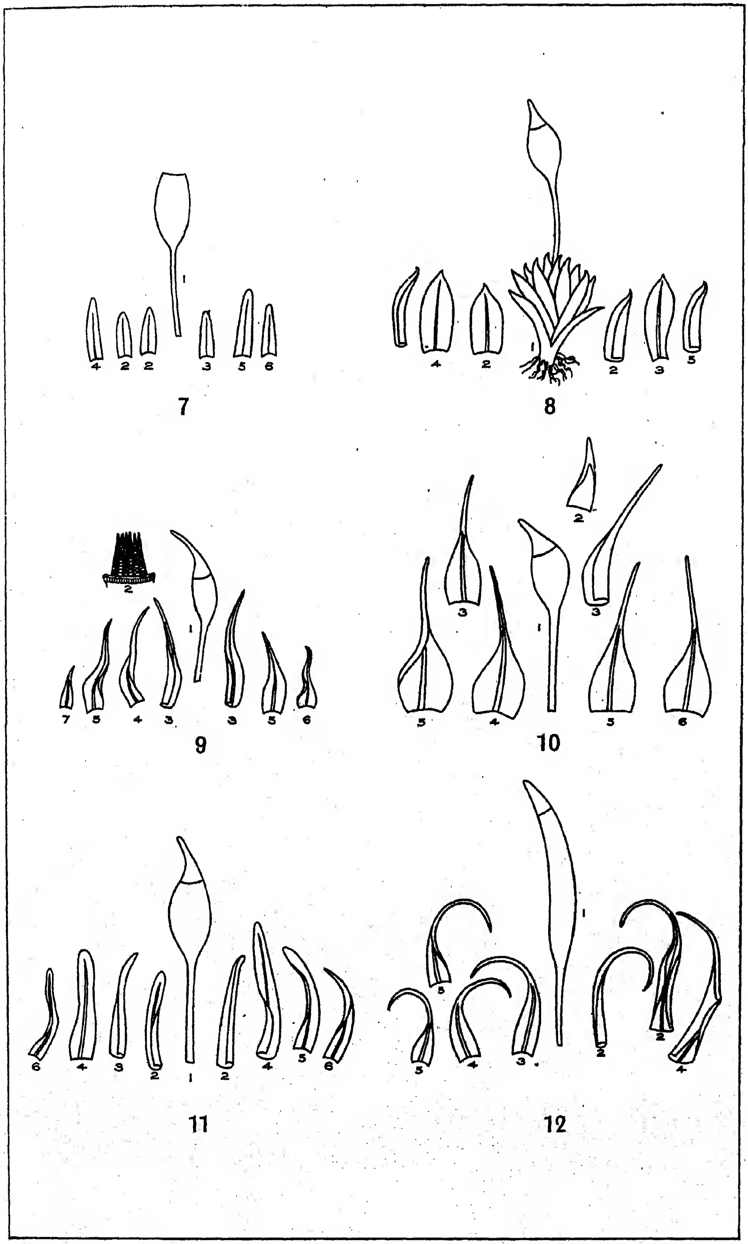

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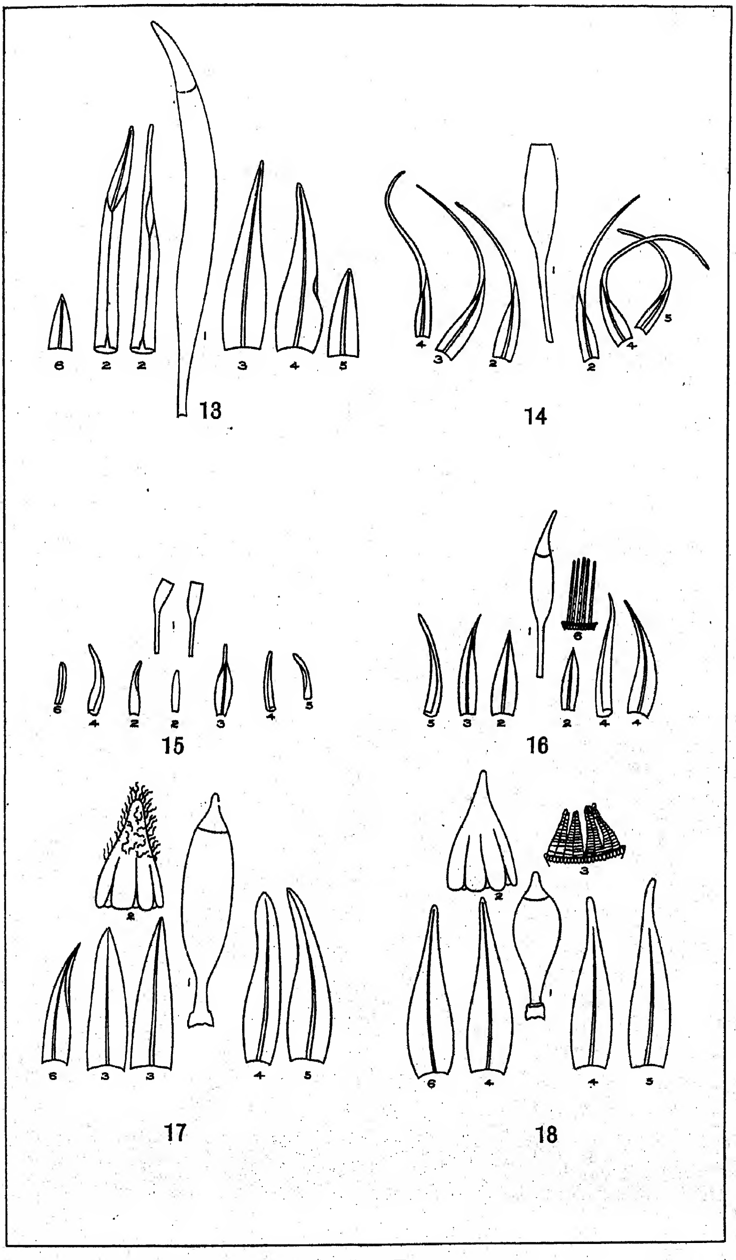
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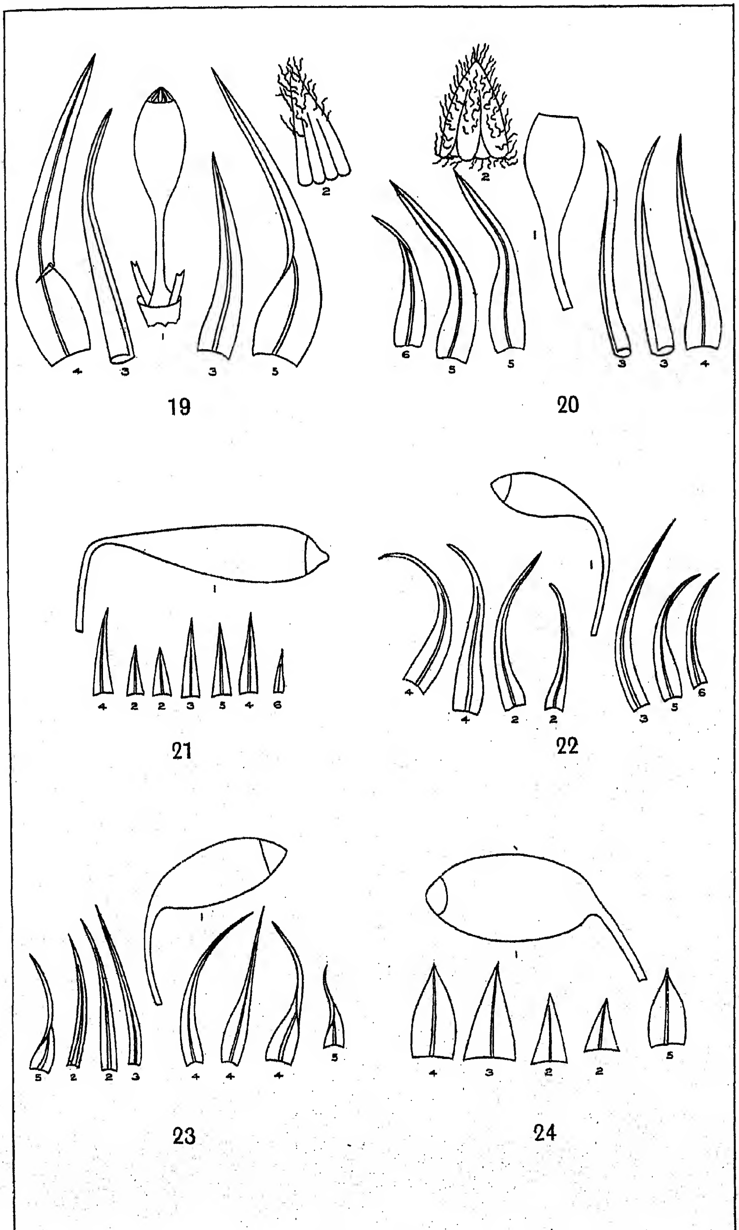

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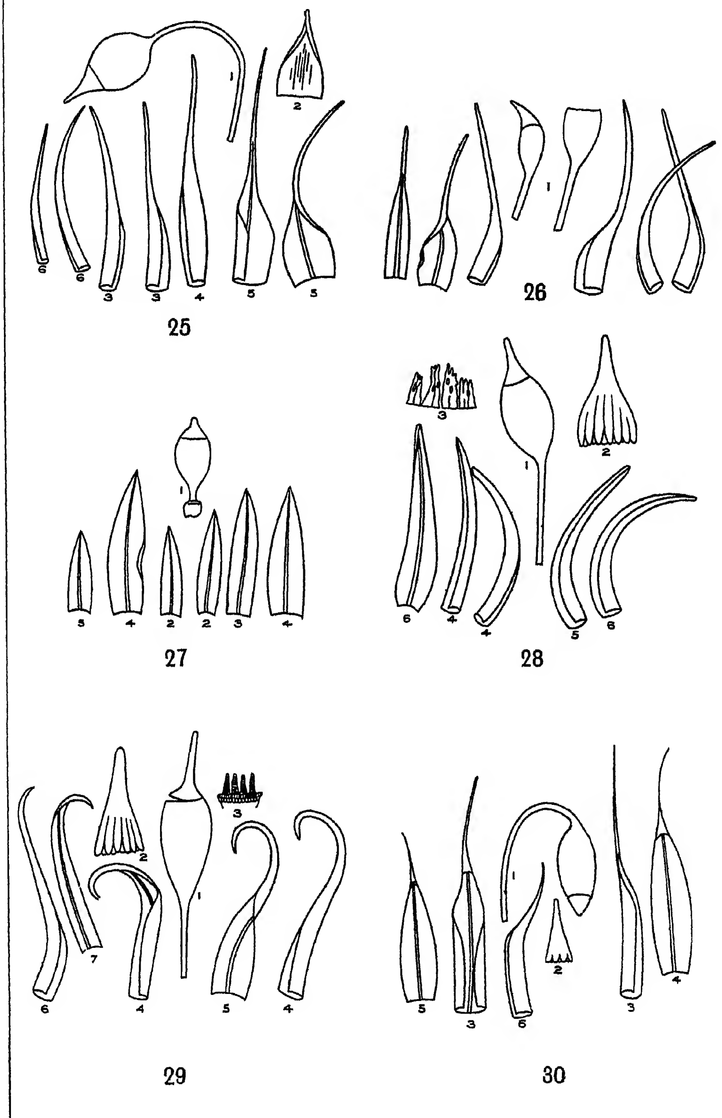

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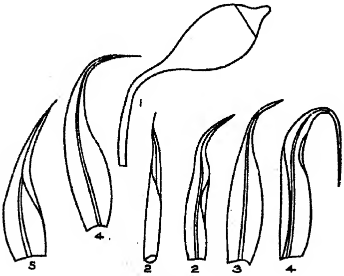

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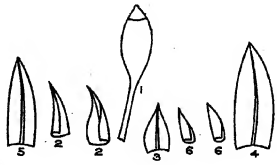

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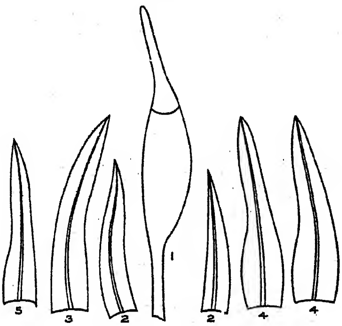

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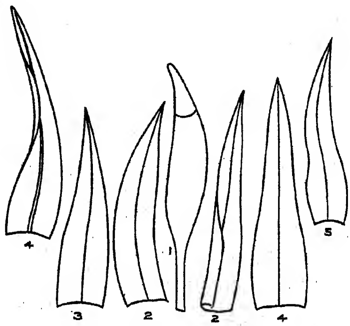

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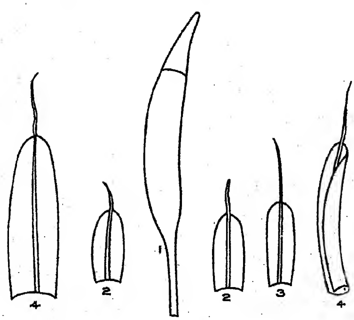

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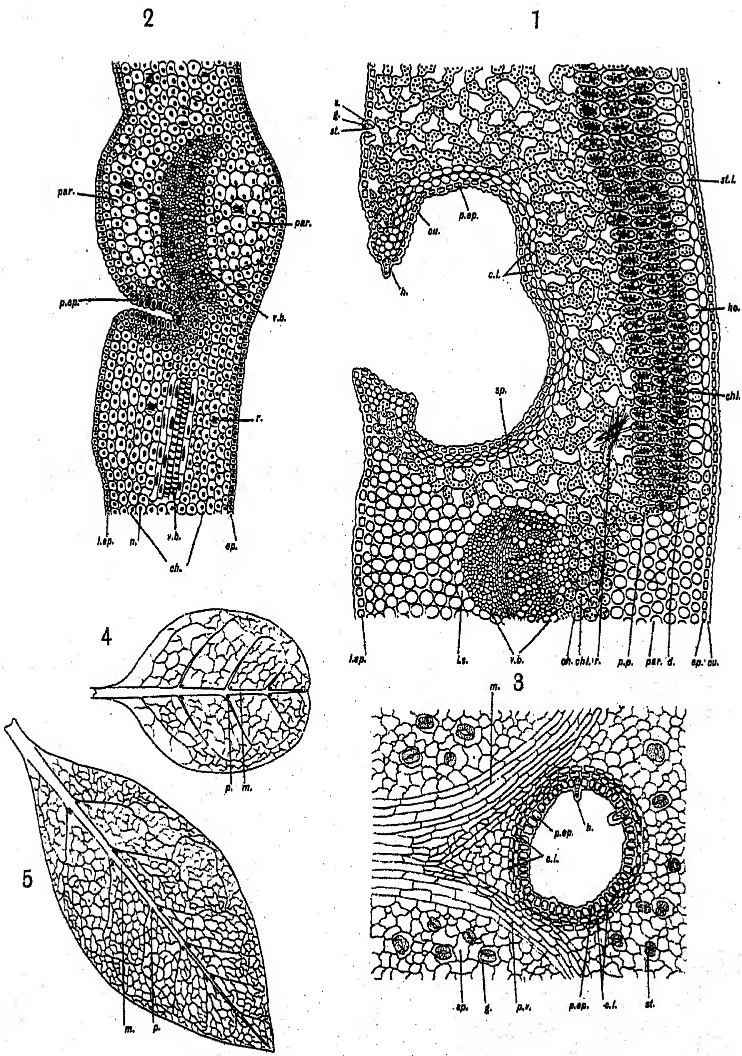

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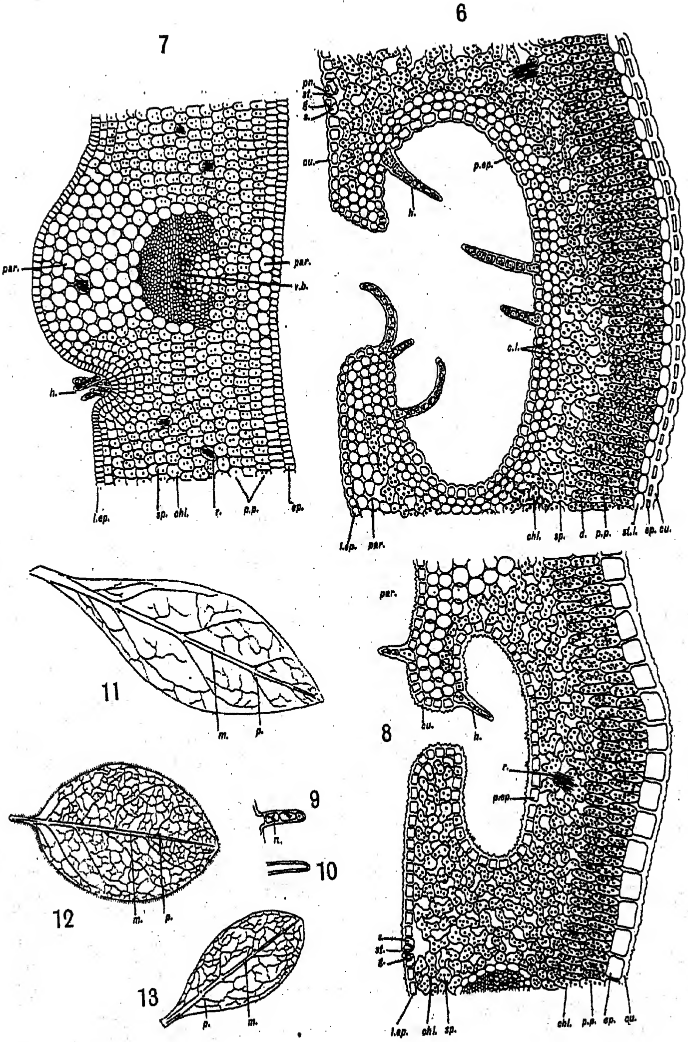

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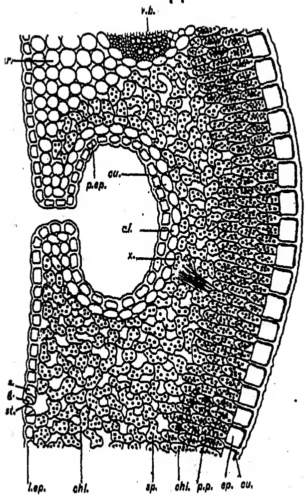

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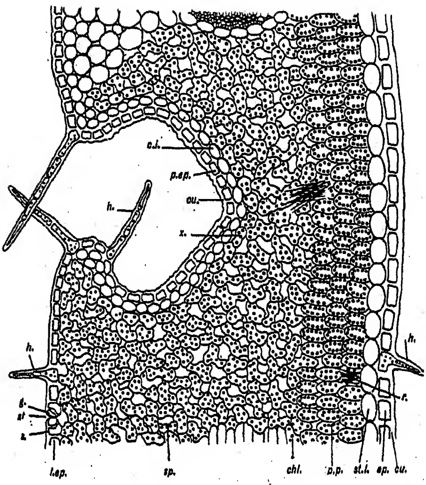

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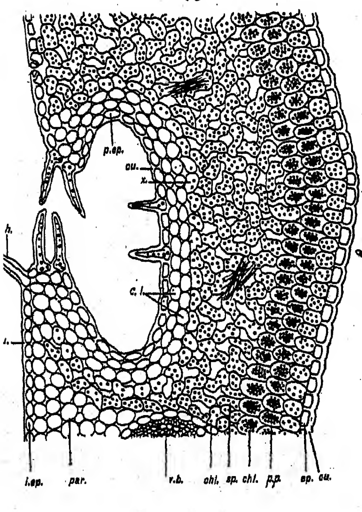

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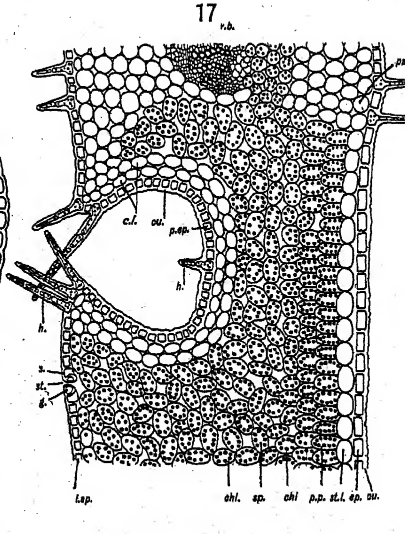

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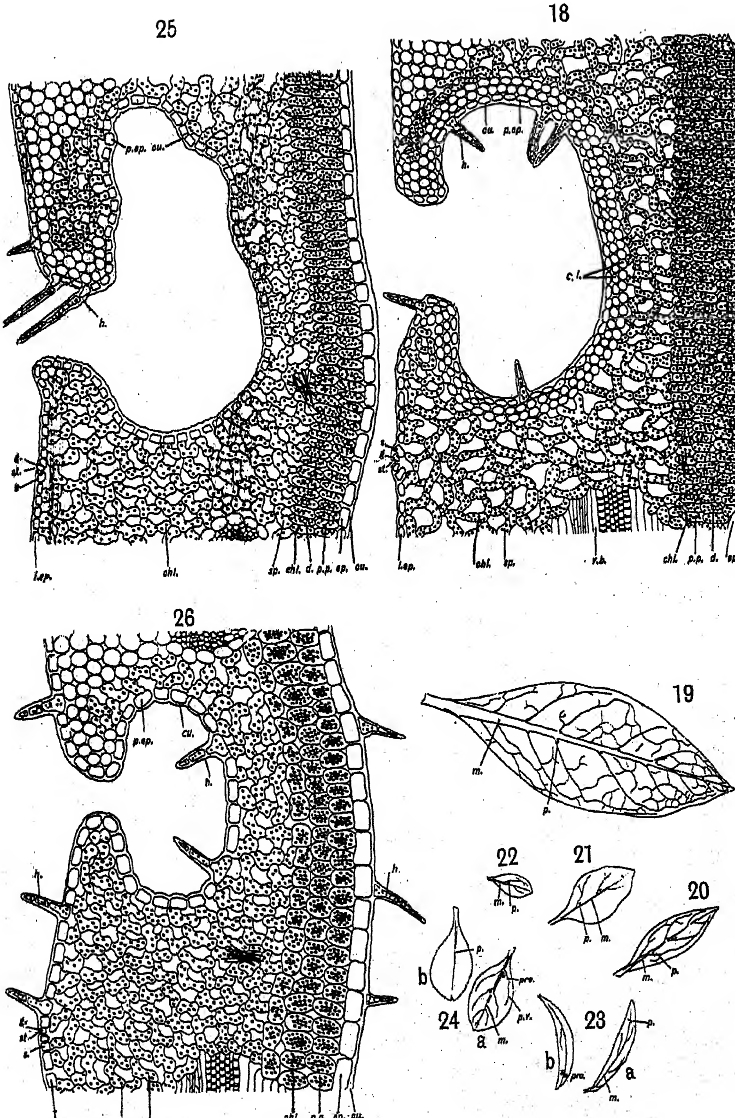

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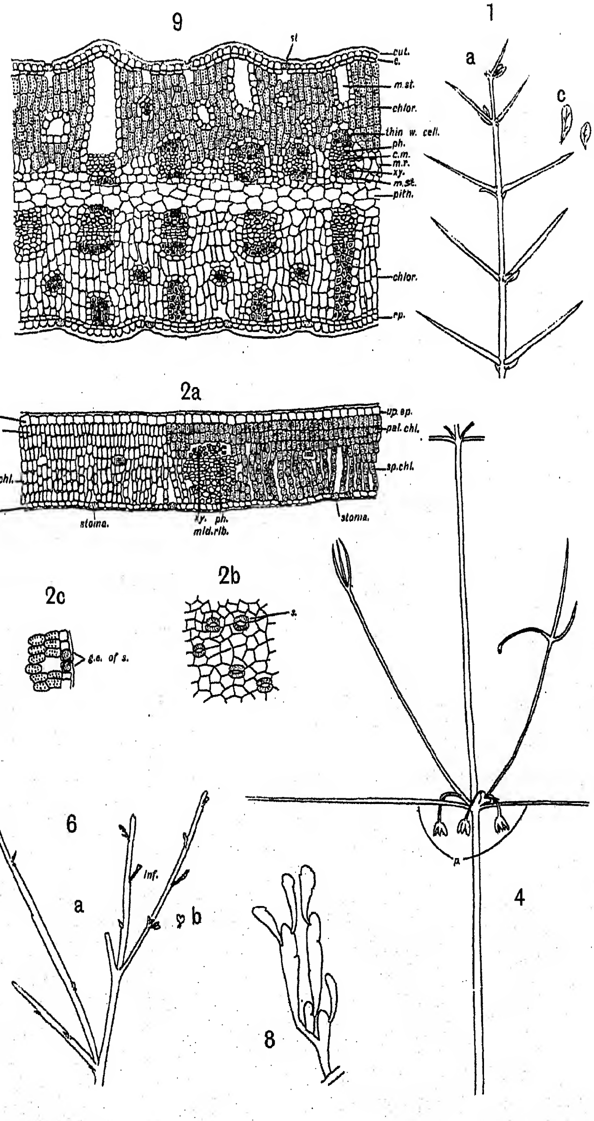

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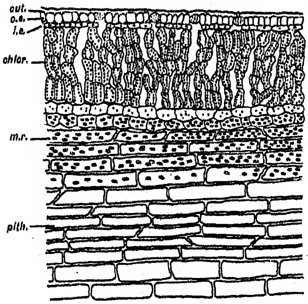

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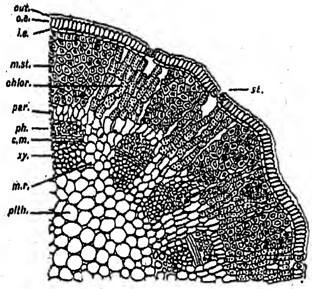

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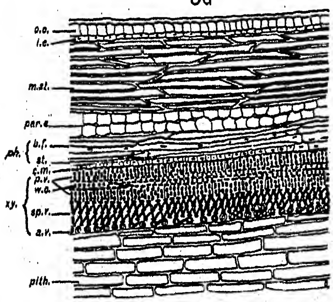

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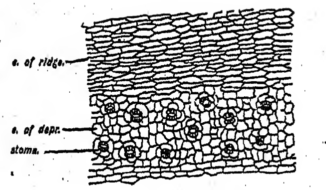

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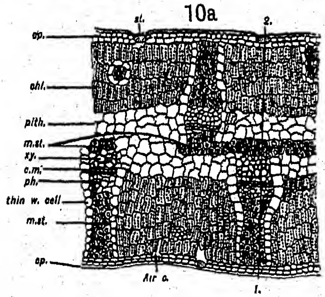

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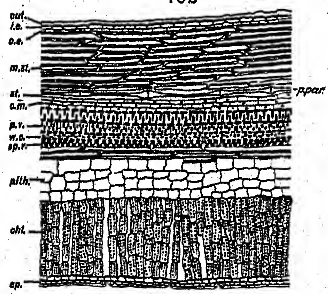

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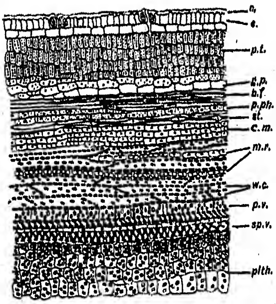

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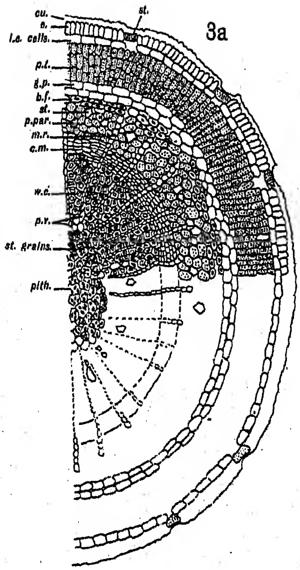

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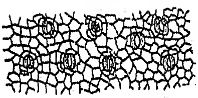

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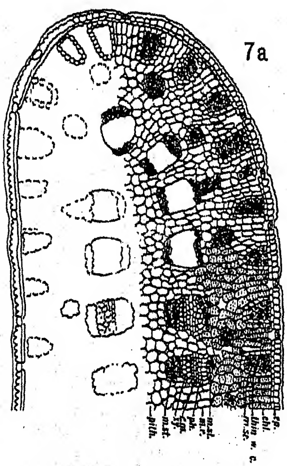

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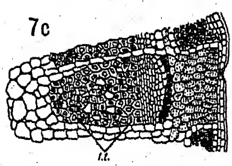

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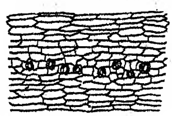

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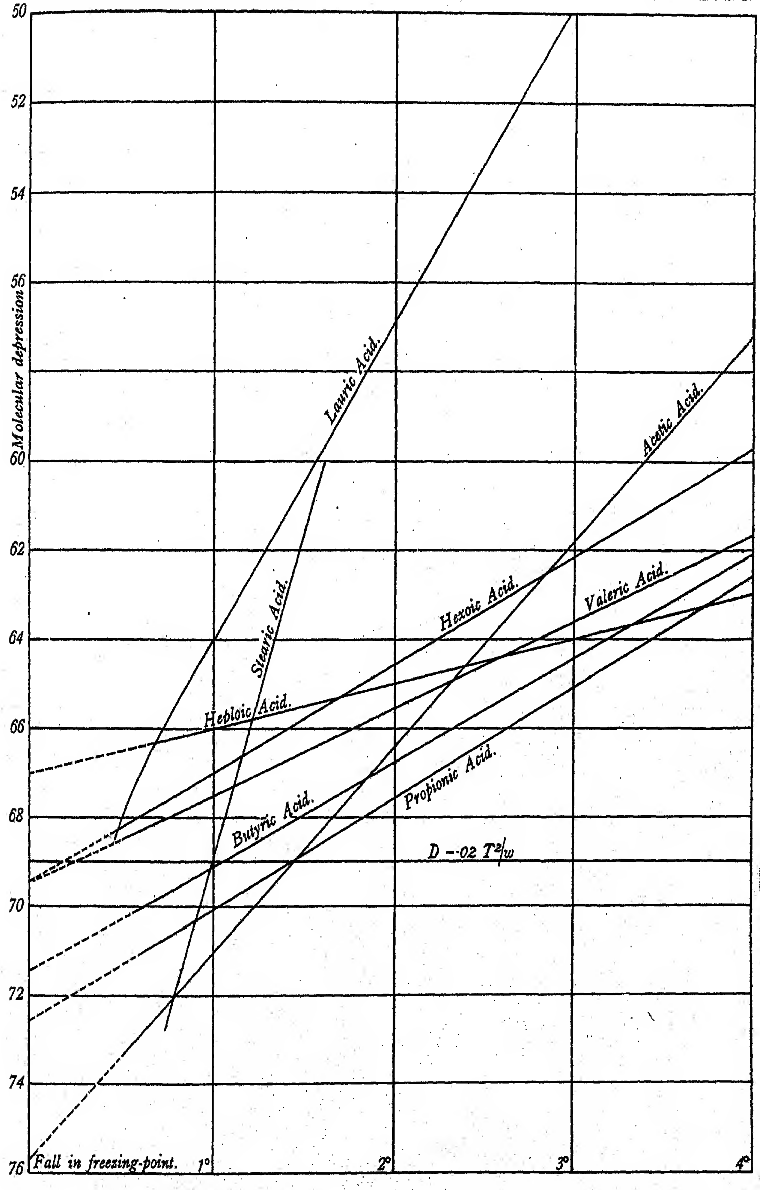

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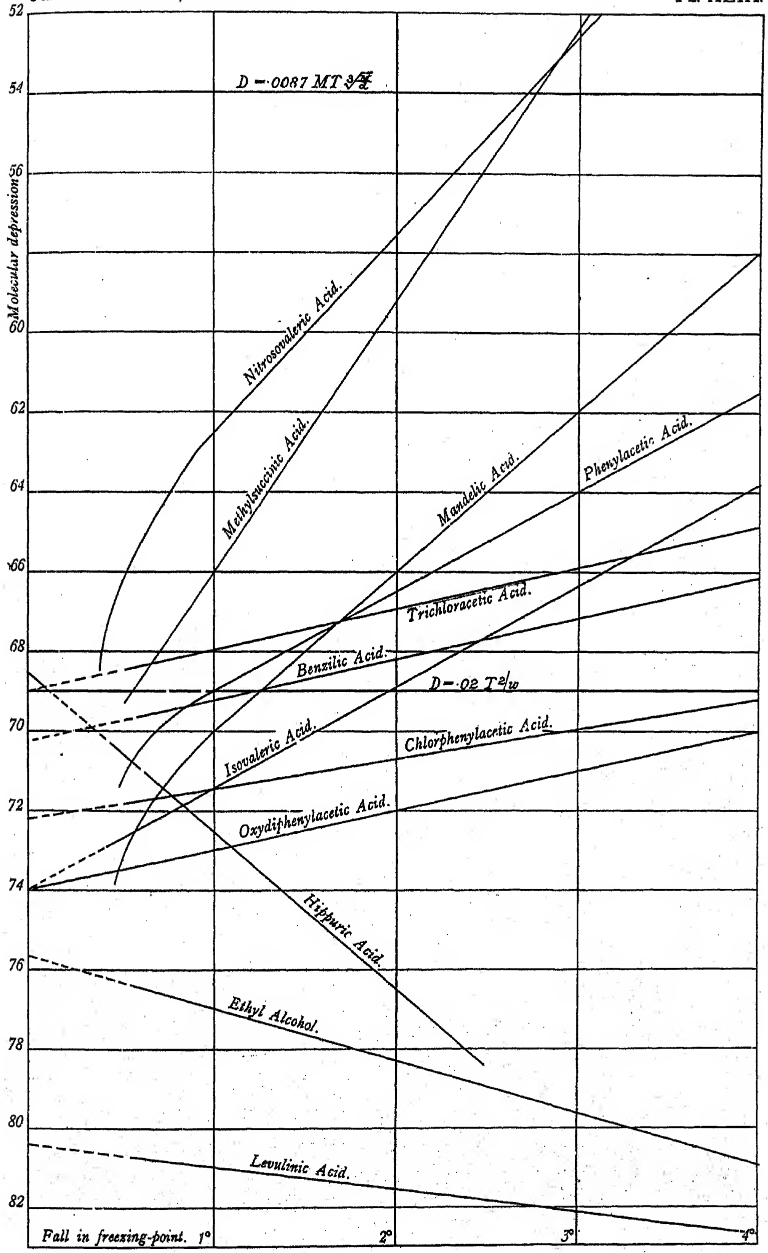

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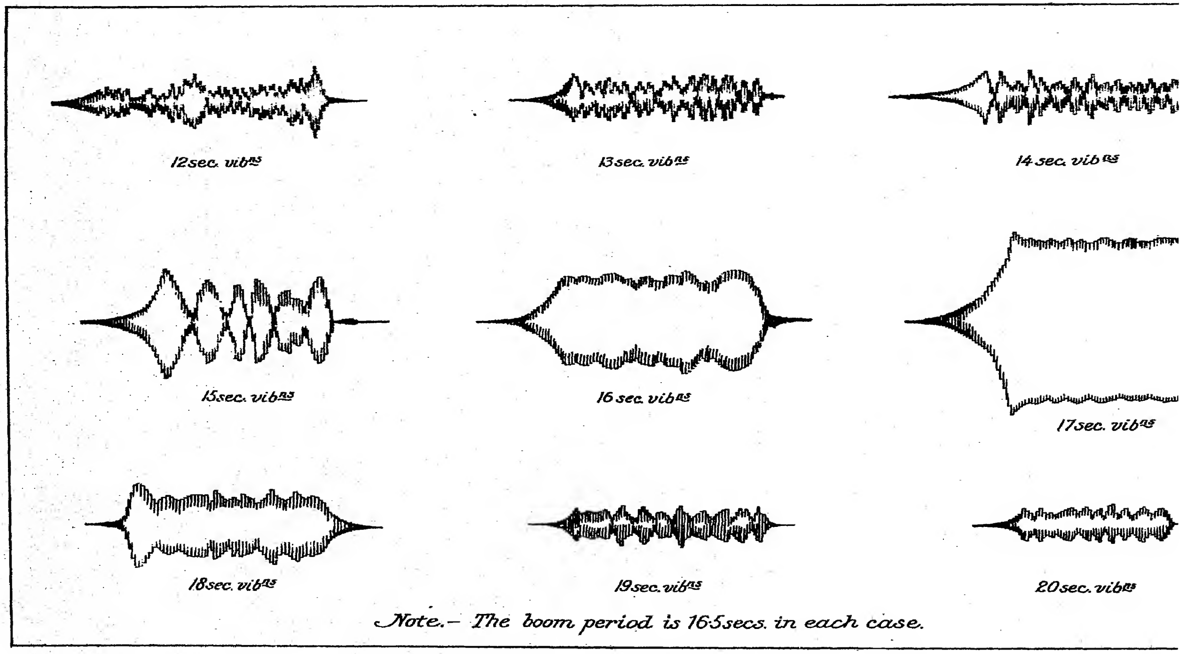

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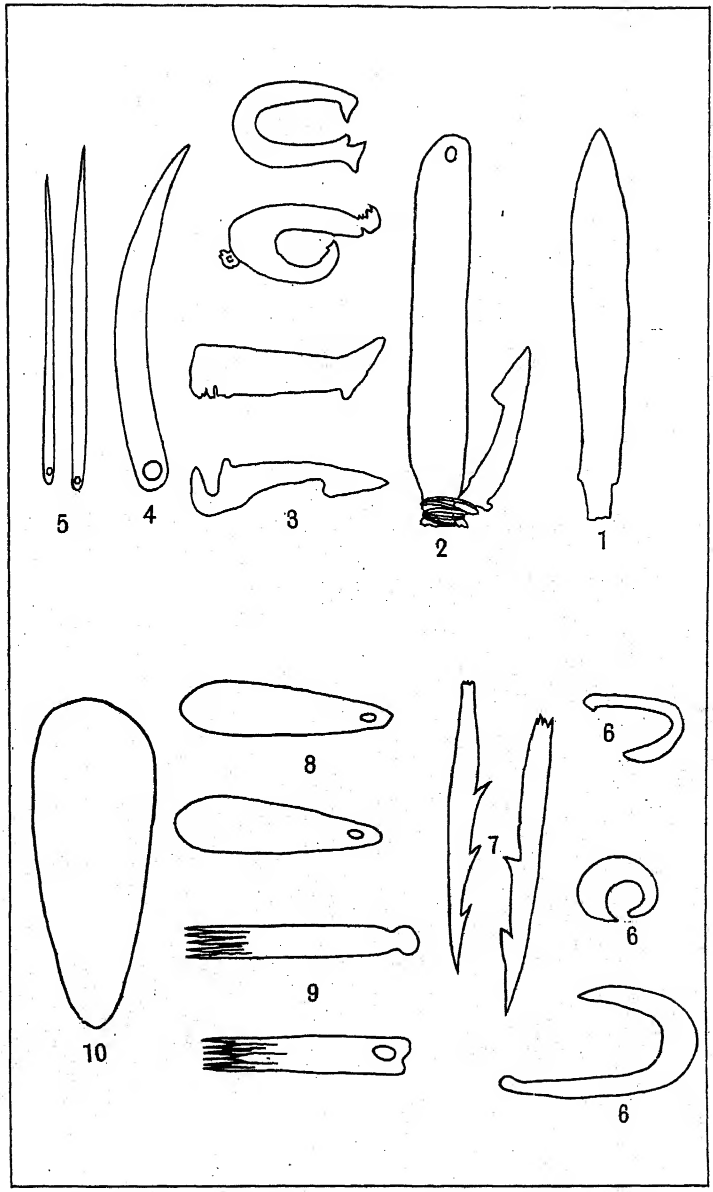

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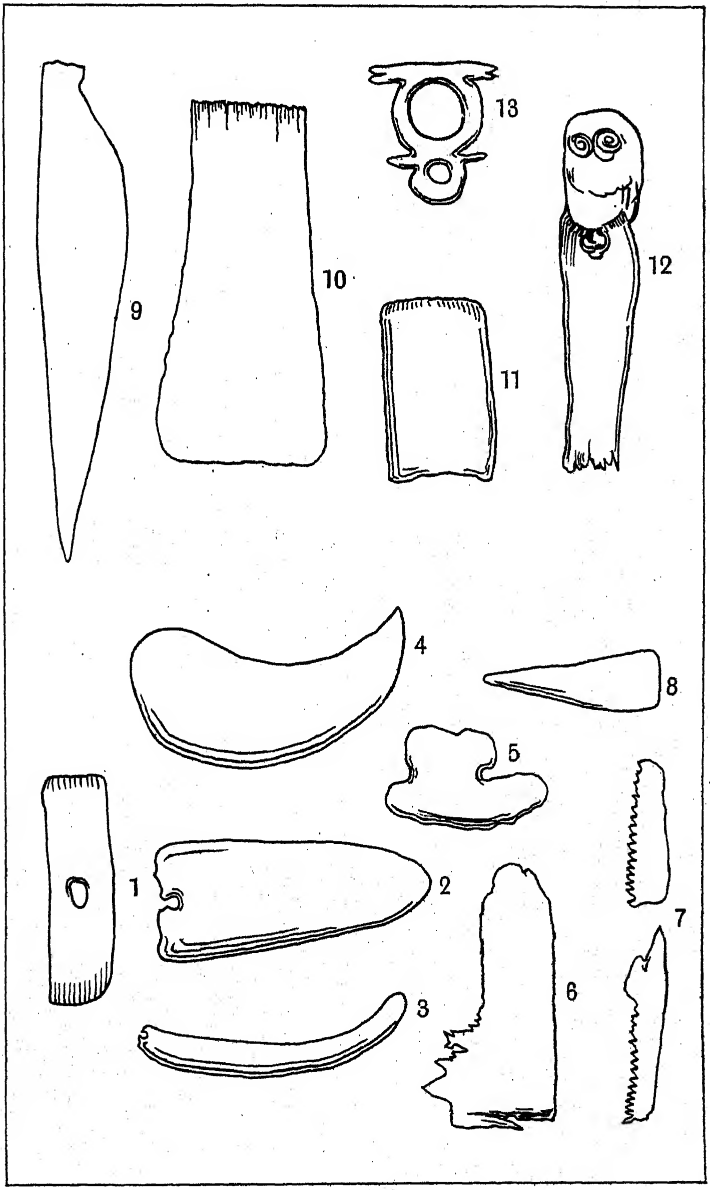

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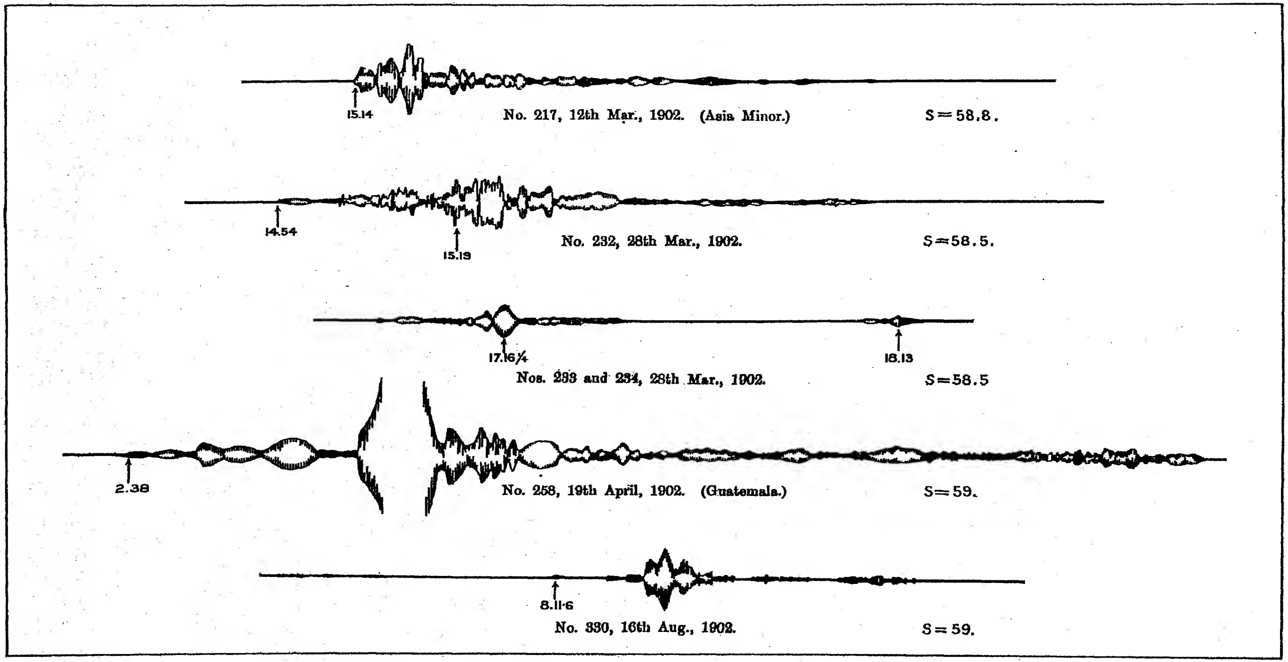
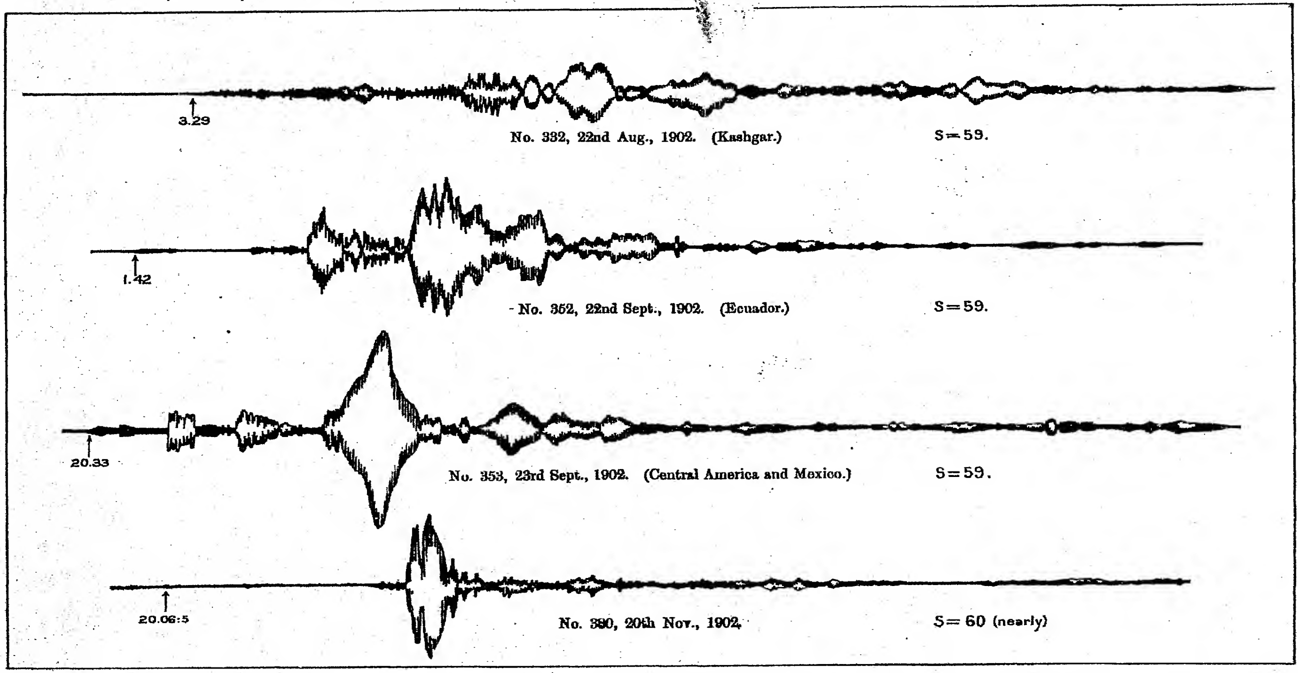


RECORDS OF MILNE SEISMOGRAPH No. 20.—Hogben.



RECORDS OF MILNE SEISMOGRAPH No. 20.—Hogben.